‘Unofficial’ NCWSS/ NEWSS Annual Meeting 2026 Proceedings



These abstracts are being made available as early as possible prior to the NCWSS/NEWSS joint annual meeting via this ‘unofficial’ proceedings document for those that prefer access to the abstracts prior to start of the meeting.

Following the meeting, the ‘Official’ 2026 Proceedings will be published and made available to the public to be used as the historical record for the society and to provide a citable source document.

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Student Poster Contest – Extension

1 - Wisconsin Herbicide Resistance Update: Where are we at?

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Herbicide-resistant weeds have long challenged Wisconsin crop production, and the number of documented resistance cases continues to increase at an alarming rate. This report provides an updated statewide timeline of unique herbicide resistance cases, defined as first confirmed weed species × herbicide site-of-action (SOA) combinations, and extends our last Wisconsin herbicide resistance overview reported in 2018. University of Wisconsin-Madison scientists have over time confirmed 31 unique herbicide resistance cases across 14 species and eight SOAs (Groups 1, 2, 4, 5, 14, 15, and 27). The first documented case was PSII-inhibitor resistance in common lambsquarters (*Chenopodium album* L.) in 1979. Between 1979 and 2026, cumulative unique cases increased linearly at 0.68 cases yr^{-1} (R^2 = 0.93); however, from 2018 to 2026, the rate increased to 0.87 unique cases yr^{-1} (R^2 = 0.69), approximately one new unique case per year, indicating that herbicide resistance in Wisconsin is accumulating fast. Recent cases include the first documented resistance to synthetic auxins (Group 4), PSII inhibitors (Group 5), VLCFA-inhibitors (Group 15), and HPPD-inhibitors (Group 27) in waterhemp, as well as the first documented case of ALS-inhibitor resistance in fall panicum in the United States. ALS-inhibitors accounted for the most cases (n = 10 species), followed by PSII-inhibitors (n = 6 species) and EPSPS-inhibitor (n = 5 species). Waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] exhibited the broadest resistance profile, with resistance confirmed in seven SOAs, whereas Palmer amaranth (*Amaranthus palmeri* S. Wats.) in four (Groups 2, 5, 9, and 27), and giant ragweed (*Ambrosia trifida* L.) and horseweed (*Erigeron canadensis* L.) each in three. Resistance to soil-applied residual herbicides has been of particular concern, as waterhemp populations resistant to PRE-applied herbicides from groups 5, 14, 15, and 27 have been confirmed, further reducing effective chemical options for growers and underscoring the importance of diversified, integrated weed management strategies.

2 - The Wisconsin Extension Weed Management Workshop: Innovative and Interactive Weed Science Education for Wisconsin Clientele.

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Wisconsin farmers and agronomists consistently identify weed management as one of the most significant challenges facing crop production. The increasing prevalence of herbicide-resistant waterhemp (*Amaranthus tuberculatus*), giant ragweed (*Ambrosia trifida*), and several grass weed species, combined

with evolving herbicide programs, weather variability, and economic constraints, have increased demand for practical, research-based weed management education. Despite numerous winter conferences, field days, and educational programs available across the state, Wisconsin previously lacked a comprehensive program focused exclusively on weed management. To address this need, the University of Wisconsin Division of Extension launched the Wisconsin Extension Weed Management Workshop in September 2024. The first year of the workshop was designed around stakeholder-identified priorities and an emphasis on actionable recommendations. Pre-workshop surveys guided topic selection, including spray technology, adjuvants, and soybean weed management in rye cover crop systems. Interactive learning activities, including a weed identification contest and weed science Kahoot quiz, supplemented classroom instruction. Post-workshop evaluations in 2024 indicated that 95% of participants learned information they could apply to land they manage, and 17 participants identified specific management changes they intended to implement. Attendance increased by 93% from 2024 to 2025, with 174 participants attending the 2025 workshop. In 2025 programming highlighted spray equipment and precision application technologies through field demonstrations featuring One Smart Spray, John Deere See & Spray, and Ecorobotix systems. This was among the first public demonstrations of these technologies in the Midwest. Survey respondents reported collectively managing more than 2.6 million acres and estimated the value of information gained at $11 to $15 per acre. In 2026, programming focused on herbicide resistance management and adjuvant selection, two of the most requested topics from previous years’ participants. Forty-six field demonstrations were established to evaluate weed control responses to varying ammonium sulfate rates across different water hardness levels with both glyphosate and glufosinate. Participants represented 21 Wisconsin counties, identified 39 distinct lessons learned, and ranked the workshop between "Above Average" to "One of the Best." Over three years, the workshop has demonstrated the value of combining stakeholder input, interactive education, and applied research demonstrations to deliver impactful weed management programming for Wisconsin agricultural clientele.

3 - 2026 Most Common and Troublesome Weed Species in Grass Crops of the North Central Region

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The Weed Science Society of America (WSSA) conducts an annual Common and Troublesome Weeds Survey of university, industry, government, consultant, and grower respondents to document the weeds most affecting them. In 2026, the survey’s focus was on six categories of grass cropping systems: corn, sorghum, spring cereal grains, winter cereal grains, pasture/rangeland/hay and turf. Participants were asked to name “Common” (most frequently encountered) and “Troublesome” (difficult-to-control) weed species. Results represent a subset of respondents from the 15 states within the North Central Weed Science Society region. In total, 1,105 weed responses were recorded, citing 180 species. Poaceae (grass), Asteraceae (sunflower), and Amaranthaceae (amaranth) families were the most represented, with 31%, 17%, and 11% of responses, respectively. Across all crops, waterhemp (*Amaranthus tuberculatus* (Moq.)), kochia (*Bassia scoparia* (L.), and Palmer amaranth (*Amaranthus palmeri*) were cited most often. Waterhemp was named 24 times as the number one most troublesome weed, more than any other species.

Kochia was concentrated in the western Great Plains (ND, NE, KS, CO) and Palmer amaranth in NE, KS and CO, while waterhemp led in the Corn Belt (IL, MO, IN, MN). Weed communities differed by crop. Amaranthaceae species led in corn and sorghum, grasses in small grains, Canada thistle (*Cirsium arvense* (L.) in pasture and crabgrass (*Digitaria* spp.) and dandelion (*Taraxacum officinale*) in turf. Widespread species such as common lambsquarters (*Chenopodium album* L.) and dandelion were seldom rated troublesome. Others, including Italian ryegrass (*Lolium perenne* L. ssp. *multiflorum* (Lam.)), ground ivy (*Glechoma hederacea* L.) and field bindweed (*Convolvulus arvensis* L.), were rated troublesome in more than 60% of their respective mentions, which suggests persistent control problems. Participating in this survey helps researchers, practitioners, and policymakers track current troublesome weeds to prioritize investment and sustainable management practices.

4 - Connecting Research, Diagnostics, and Extension: Two Years of the Herbicide Resistance Monitoring Network (HERMON)

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Herbicide resistance is an increasing challenge for soybean production in the United States, highlighting the need for coordinated research, reliable diagnostic tools, and effective information-sharing networks. The Herbicide Resistance Monitoring Network (HERMON), launched in 2025 and led by Michigan State University with support from a $500,000 grant from the United Soybean Board, brings together researchers and extension specialists from 10 universities across the United States. The network aims to strengthen the detection, diagnosis, monitoring, and management of herbicide-resistant weeds through collaborative research and the development and dissemination of practical tools and resources.

During its first two years, HERMON has supported more than 23 research projects addressing herbicide resistance in major soybean weeds, including waterhemp, Palmer amaranth, common and giant ragweed, horseweed, and other problematic species. Research activities have focused on characterizing both target-site and non-target-site resistance mechanisms across multiple herbicide modes of action, developing and validating rapid diagnostic approaches, and expanding shared collections of resistant and susceptible weed populations to support a coordinated germplasm database and resistance mapping. The network has established 12 internal collaborations and partnerships with more than five external partners in academia and industry, supported more than 13 graduate students and postdoctoral researchers, and generated more than 10 manuscripts that have been published, are under review, or are in preparation. Extension and outreach have been central to the network’s work. HERMON members have delivered more than 80 presentations, reaching over 7,000 stakeholders directly, alongside newsletter articles, radio interviews, and dedicated podcast episodes. The HERMON video series has released more than 18 videos, accumulating over 8,600 views across YouTube and the TakeAction platform.

In its third year, HERMON will strengthen collaborations established during its first two years, complete the validation of rapid diagnostic tools across partner institutions, and expand the germplasm database and resistance mapping efforts to additional weed species. The video series and podcast will also continue to deliver research findings to growers, agronomists, and extension educators. These efforts will further advance coordinated herbicide resistance monitoring and support more informed weed-management decisions in soybean production.

5 - Endangered Species Act

Bill Chism[1]

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The WSSA Endangered Species Act Committee is asking what communication, education, or outreach materials you need that are not already on our webpage WSSA.net/endangered-species?

Student Poster Contest – Equipment and Application Methods

6 - Machine learning based classification of drift reducing adjuvants and their impact on droplet size and morphology

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Spray drift remains a major concern in pesticide applications, particularly with unmanned aerial systems (UAS), where fine droplets are susceptible to off-target movement. This study evaluated three drift reduction agents (DRAs: WeatherGard, Interlock, and Liberate) mixed with glufosinate using a CO_2-pressurized backpack sprayer equipped with an XR11002 nozzle (140 L ha^{-1}) and a UAS rotary atomizer (37.4 L ha^{-1}) at nominal droplet-size settings of 250 and 350 µm. Water and glufosinate alone served as controls. Droplet size and morphology were evaluated using water-sensitive paper, statistical analysis, and hybrid machine learning. A significant application method × spray solution interaction affected volume median diameter (VMD; $F = 56.33$, $p < 0.0001$), demonstrating platform-dependent DRA responses. With the backpack sprayer, glufosinate + Liberate produced the largest VMD (387.1 µm), increasing droplet size by 15.4% relative to glufosinate alone, compared with 3.8% and 6.0% for Interlock and WeatherGard, respectively. At the UAS 250-µm, Interlock and WeatherGard increased VMD to 320.4 and 321.5 µm (30.6% and 31.0%, respectively), whereas Liberate increased VMD to 289.3 µm (17.9%). At the UAS 350-µm, Interlock and WeatherGard produced VMDs of 366.4 and 366.5 µm (6.5% increases), compared with 1.9% for Liberate. DRAs significantly altered droplet circularity, aspect ratio, solidity, elongation, and compactness ($p < 0.001$), with Interlock producing the greatest reduction in circularity and solidity and Liberate the strongest elongation response. Hybrid machine learning integrating droplet morphology, deposition metrics, and image-derived features distinguished DRA treatments from controls,

with XGBoost achieving the highest performance (accuracy = 0.806; ROC-AUC = 0.860). These findings highlight the importance of selecting DRAs according to atomization system and droplet-size.

7 - Quantifying Adjuvant Performance Through Shikimic Acid Accumulation

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Adjuvants are added to pesticide applications to improve efficacy, but their contributions can be difficult to detect with standard greenhouse evaluations. Visual injury ratings and shoot biomass capture the whole-plant outcome, but they require up to two weeks and may miss adjuvant benefits that occur shortly after application. Shikimic acid (SA) accumulates in treated tissue within hours and can be quantified spectrophotometrically, providing a quantitative measure of glyphosate activity. Greater SA accumulation could be an indicator of adjuvant influence on glyphosate efficacy. The objective of this research was to determine whether a SA colorimetric assay could detect early differences among adjuvant treatments and serve as an indicator of final efficacy. Smooth pigweed (*Amaranthus hybridus* L.) plants were treated with glyphosate alone or with two different high surfactant oil concentrate (HSOC) adjuvants (HSOC-crop oil and HSOC-methylated seed oil) and compared to an untreated control. Tissue was collected 1, 5, and 24 hours after application (HAA) from the three newest leaves of an individual plant for SA quantification. Biomass was measured 7 days after application (DAA). Shikimic acid accumulation was detectable in glyphosate treatments as early as 1 HAA and was 420 to 560% greater than the untreated control by 24 HAA. Glyphosate and glyphosate + adjuvant treatments reduced biomass 84 to 86% 7 DAA. The greatest numerical biomass reduction was measured with glyphosate + HSOC-methylated seed oil, but the greatest numerical concentration of SA at 24 HAA was measured with glyphosate alone. A low number of replications and variability in leaf age among the three sampled leaves resulted in limited statistical differences. This assay provides rapid, quantitative evidence of glyphosate activity. However, early SA accumulation did not separate adjuvant treatments or predict biomass reduction under the conditions tested. The current method does not serve as an indicator of adjuvant performance, but refining sampling time, leaf selection, and replication may improve its ability to separate adjuvant treatments.

8 - Effects of Adjuvant Selection on Epyrinacil Performance and Spray Deposition

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As new challenges arise in weed management, including herbicide resistance, the need for novel management options grows. A recently introduced product containing the active ingredient epyrifenacil

offers an additional option for fast, broad-spectrum preplant burndown of broadleaf and grass weeds. Similar to other herbicides with the same mode of action (protoporphyrinogen oxidase [PPO] inhibitors), adjuvant use may be recommended. However, limited information is available regarding adjuvant performance in combination with epyrifenacil. This study aims to investigate the effects of adjuvant selection on efficacy and spray deposition. Treatments included four types of adjuvants (non-ionic surfactant (NIS), high surfactant methylated seed oil (HSMO), deposition aid, and high surfactant oil concentrate (HSOC)) applied alone and in combination with 10.07 g ai ha^{-1} epyrifenacil. Use rates of NIS and deposition aid were 0.33% v v^{-1}, while HSMO and HSOC were added at 0.42% v v^{-1}. Droplet size distribution was determined in a low-speed wind tunnel equipped with a Sympatec HELOS laser-diffraction system. Deposition characteristics and efficacy were measured by spraying treatments in a three-nozzle single-track spray chamber equipped with PSLDMQ12004 nozzles calibrated to deliver 140 L ha^{-1} at 276 kPa. Traveling velocity was 3.54 m s^{-1}, with nozzle spacing and boom height at 50.8 cm. All solutions containing food-grade dye at 2 g L^{-1} were sprayed onto kromekote cards and analyzed for percent coverage. *Setaria viridis* (L.) P. Beauv (green foxtail), *Chenopodium album* L. (common lambsquarters), *Amaranthus palmeri* S. Watson (Palmer amaranth), and *Abutilon theophrasti* Medicus (velvetleaf) were treated at 7.5 to 12.5 cm. The addition of all adjuvants overall decreased the droplet size of the total spray volume, thus increasing the percent of droplets less than 141 µm (driftable fines), with the HSOC resulting in the least driftable fines and coverage at 1.1 and 38.9%, respectively. The addition of HSMO and a deposition aid increased spray coverage from 43.9% with epyrifenacil alone to 47.3% and 46.6%, respectively. Adjuvant addition improved visual weed control across all evaluated species at 4 hours and 1 day after application; however, no differences in biomass reduction were observed. The effect of adjuvant addition was particularly evident in green foxtail, where biomass reduction increased from 57.6% with epyrifenacil alone to an average of 84.7% with adjuvants. These findings highlight the flexibility in adjuvant selection to achieve different droplet size profiles, spray coverage, and drift reduction potential while maintaining comparable overall weed control efficacy, depending on application and environmental conditions.

9 - Turning Weed Maps Into Herbicide Prescriptions: Precision Management or Unnecessary Complexity?

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Spatial variability in weed populations creates an opportunity to adjust residual herbicide inputs based on weed density rather than applying a uniform rate across the entire field. Historical weed-density maps created by targeted herbicide application technologies may provide a practical basis for developing variable-rate preemergence (PRE) herbicide prescriptions. Field studies were conducted in Kansas during 2025 and 2026 to evaluate the use of historical weed-density maps for variable-rate PRE herbicide applications in soybean (*Glycine max* L.). Single-rate and variable-rate treatments were arranged in replicated strips that followed the sprayer's passes. Weed-density maps from the previous season were used to identify polygons with high and low weed densities. In 2025, two herbicide rates were tested at two fields (Raytheon and SAA): sulfentrazone at 0.25 and 0.28 kg ai ha^{-1} and acetochlor at 1.47 and 1.68

kg ai ha^{-1}, with samples collected inside and outside high-weed-density polygons. In 2026, the study was conducted at two different fields (Feedlot and The-80), and sulfentrazone and pyroxasulfone were expanded to three rates. The medium (label-recommended) rate was 0.326 kg ai ha^{-1} sulfentrazone and 0.164 kg ai ha^{-1} pyroxasulfone. Variable-rate treatments used lower and higher rates of sulfentrazone (0.235 and 0.420 kg ai ha^{-1}) and pyroxasulfone (0.119 and 0.210 kg ai ha^{-1}), respectively. Carrier volumes of 94, 131, and 168 L ha^{-1} were used to achieve the low, medium, and high rates, respectively. The single-rate strips received the medium rate, while the variable-rate strips received the high rate within the mapped polygons with high weed density and the low rate in polygons with low weed density reported. Weed control and crop injury were visually evaluated, and soybean stand, chlorophyll content (SPAD), plant height, node number, and yield were also measured. Data were analyzed using three-way mixed-model ANOVA and Tukey’s test. In 2025, weed control ranged from 93 to 99% at Raytheon and SAA and was similar between treatments. At Raytheon, soybean injury 3 WAP was 11% with the single-rate treatment and 7% with the variable-rate treatment, but was similar at 7 WAP. Other soybean response variables, including yield, did not differ between treatments. In 2026, weed control at Feedlot was 98-99% across both treatments. At The-80, control 3 WAP was greater with the single-rate treatment than with the variable-rate treatment, 94 versus 90%, but was similar by 7 WAP at 99 and 98%, respectively. Crop injury and soybean response did not differ between treatments in either of the 2026 fields. Yield also showed no significant treatment differences at either location in 2026. These results showed that when the standard residual herbicide rate already provides good control, adding greater prescription rates may not be necessary to improve weed control; however, applying a reduced rate in areas with no weed pressure did not reduce weed control. More work is needed to determine whether the savings in herbicide use and the economic returns justify the added complexity of variable-rate application.

Keywords: variable-rate herbicide application, weed control, weed-density maps, site-specific, crop injury, preemergence, soybean, prescription mapping

10 - Are We on Target? Evaluating UAV Platforms for Targeted Spraying.

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As herbicide applications with unmanned aerial vehicles (UAV) become increasingly popular, research is needed to understand field efficacy of UAV applications. Most UAV in the marketplace currently have the ability to utilize variable rate application (VRA) maps. However, little research has been conducted to effectively determine if UAV can accurately apply pesticide with VRA maps, specifically in spot spray application scenarios. Spot spray applications can reduce chemical cost and increase field efficiency while only targeting areas where a pesticide application is needed. A field experiment was conducted in both 2025 and 2026 to assess the performance of a UAV spot spray application using a DJI Agras T40, T50, and an EA Vision J150. Five, 3-by-3 m targets were randomly placed within a 61-by-61 m area. Target areas were mapped using a DJI Mavic 3M and VRA maps generated in Pix4DFields. Lines of receipt paper were placed in the center of each target area extending 12 m in each direction making two 24 m lines (X and Y). An application of 0.3% v/v food grade #1 blue dye was made at 28 L/ha with each UAV

to visually understand spatial variation of coverage and droplet density around targeted areas. All receipt paper was analyzed with the SwathGobblerPro software. The T40 UAV exhibited increased coverage and droplet density on both the X and the Y lines when compared to the T50. Applications with the T50 resulted in greater spray coverage and droplet density within an area approximately 1.8 m below the center of the intended target. Both the T40 and T50 resulted in significantly greater spray coverage within the intended 3-m target area along the X axis compared to areas outside of the target. These results indicate that both UAV platforms are capable of targeting specific areas using VRA maps; however, differences in spray deposition between platforms suggest that application accuracy and uniformity may vary depending on the UAV utilized.

11 - A Comparison of Boom Height and Applicator Bar Design for Weed Electrocution.

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Weed electrocution is an alternative weed control method that has been shown to be effective on numerous summer annual weed species. However, control can be variable and some species are more prone to survival. A field experiment was conducted in 2026 to 1) compare the effectiveness of a new scratch-pad applicator (SPA) bar design with the conventional (CONV) applicator bar on The Weed Zapper™ electrocution implement and 2) determine the influence of applicator bar height on weed control. Treatments were arranged in a randomized complete block design and consisted of both applicator bars positioned at either 60- or 91-cm above the soil surface on waterhemp (*Amaranthus tuberculatus*) plants that averaged 103 cm in height at the time of application. Visual weed control ratings and UAV-based multispectral measurements were collected at regular intervals following treatment and waterhemp biomass was determined 28 days after treatment (DAT). Regardless of applicator bar design, greater weed control and lower waterhemp biomass were generally observed when treatments were applied at a height of 60 cm compared to 91 cm. The SPA bar positioned at 60 cm resulted in significantly lower waterhemp biomass (93.7 g/m2) than the CONV bar positioned at either 60 or 91 cm (202.8 and 215.7 g/m2, respectively). However, visual waterhemp control did not differ significantly between the SPA bar and the CONV bar when compared at the same height 28 DAT. These results indicate that applicator bar height has a greater influence on overall weed control than applicator bar design, although the new SPA design should provide comparable levels of waterhemp control as the CONV applicator bar.

12 - Can Uncrewed Aerial Systems Replace Grain Drills for Seeding Cover Crops?

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Cover crops suppress weeds when they establish well and produce enough biomass, but those seeded after cash crop harvest have little time to do so before winter. Uncrewed aerial systems (UAS, or drones) can broadcast seed into a standing crop before harvest, extending the fall establishment period. However, surface-broadcast seed may have poor seed-soil contact, particularly under no-till or heavy residue, limiting emergence. Tillage may improve seed-soil contact, and irrigation may support germination and early growth when soils are dry. The objective was to compare UAS and drill seeding for cereal rye (*Secale cereale* L.) establishment and determine whether interseeding timing, tillage, or irrigation improves UAS-seeded stands. Two field studies were conducted at the Eastern Shore Agricultural Research and Extension Center in Painter, VA, in 2025-2026. In both studies, rye was seeded at 163 kg ha^{-1} with a DJI Agras T50 UAS or at 123 kg ha^{-1} with a tractor drill. The first study was a split-split plot design with three replications: irrigation (irrigated or non-irrigated; main plots), tillage (disked to 15 cm or no-till; subplots), and seeding method (sub-subplots); no-till soybean [*Glycine max* (L.) Merr.] followed the rye. The second study compared UAS interseeding into standing soybean 3 weeks before harvest, UAS seeding after harvest, and drill seeding after harvest in a no-till randomized complete block design with three replications; no-till corn (*Zea mays* L.) followed. Rye biomass was sampled in spring before termination, and overall weed control in the following crop was visually rated (0 to 100%) 21 days after planting. UAS seeding produced lower rye stand density than drilling in both studies, even at a 33% higher seeding rate: 190 vs. 310 plants m^{-2} in the irrigation × tillage study ($P < 0.001$) and 235 plants m^{-2} for each UAS timing vs. 370 plants m^{-2} for the drill in the interseeding study ($P = 0.012$), possibly reflecting poorer seed-soil contact. Tillage increased rye biomass from 1,200 kg ha^{-1} under no-till to 1,900 kg ha^{-1} with tillage ($P = 0.025$) and stand density from 210 to 290 plants m^{-2} ($P = 0.001$), whereas irrigation alone did not affect biomass ($P = 0.344$). In the interseeding study, UAS-interseeded rye produced biomass similar to drilled rye (3,600 and 3,900 kg ha^{-1}), and both exceeded UAS seeding after harvest (3,000 kg ha^{-1}; $P = 0.005$). Soybean weed control was similar with UAS and drill seeding under irrigation (86 and 87%, respectively) but lower with UAS seeding without irrigation (79 vs. 90%; seeding method × irrigation interaction, $P = 0.003$). In corn, weed control averaged 98% across seeding methods. Overall, UAS interseeding before soybean harvest produced rye biomass comparable to drilling despite lower stand density. Tillage improved rye establishment, while without irrigation, UAS-seeded rye provided less weed control than drilled rye.

13 - Evaluation of a Novel Nanocellulosic Adjuvant for Drift Reduction in Agrochemical Applications

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Spray drift remains a major challenge in pesticide applications, reducing application efficiency and increasing the risk of off-target damage. This research evaluated the effects of a novel nanocellulosic adjuvant (BioGrip EC) on spray droplet characteristics, downwind drift, and in-swath spray deposition compared with a commercial drift reduction adjuvant (Intact) and water alone. Laboratory experiments evaluated droplet size distributions from three spray solutions [water alone, Intact (0.5% v/v), and BioGrip EC (0.5% v/v)] across multiple nozzle types (AIXR and TTI 11004) using an image-based spray

analyzer (Oxford Laser, VisiSize P15, Shirley, MA 01464, USA). The spray patterns were traversed through the imaging plane to sample the entire spray plume, and 7,500 individual droplets were sampled. A field drift experiment was conducted in May 2025 at the Throckmorton-Purdue Agricultural Center in Indiana using a self-propelled sprayer equipped with MR11005 nozzles operated at 359 kPa and an application volume of 140 L ha^{-1}. The aforementioned spray solutions were evaluated with five replications. Spray deposition was quantified using a fluorescent tracer (PTSA dye) collected on Mylar cards positioned in-swath and up to 61 m downwind. Kromekote cards were analyzed using Python-based image processing to quantify spray coverage, deposit density, and deposit-based droplet size. Laboratory results showed that BioGrip EC reduced the relative span and driftable fines (% of droplets <200 µm in diameter) from 1.38 to 1.21 and 55.0 to 43.0%, respectively, compared with water alone when applied through an AIXR11004 nozzle. However, responses varied among nozzle types. In the field, modeled in-swath deposition was 85.1% for BioGrip EC, compared with 71.6% for Intact and 66.8% for water alone. The predicted downwind distances for a 90% reduction in deposition were 2.72, 2.76, and 3.83 m for BioGrip EC, Intact, and water alone, respectively. BioGrip EC significantly reduced this distance compared with water alone and performed similarly to Intact. In-swath assessments showed no differences among treatments in deposit-based droplet diameter, spray volume, coverage, or deposit density. These findings indicate that BioGrip EC can reduce downwind spray drift while maintaining in-swath spray characteristics comparable to a commercial drift reduction adjuvant, demonstrating its potential as an alternative technology for drift mitigation in pesticide applications.

14 - Effects of Drift-Reducing Agents on Dicamba Spray Coverage, Drift Potential, and Crop Safety

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Dicamba is an effective weed control tool in dicamba-tolerant soybeans. However, because of the elevated risk of off-target particle movement (drift), proper application guidelines must be followed to minimize it, including the required use of drift-reducing agents (DRAs). DRAs mixed with different herbicides may reduce drift risk; however, they may also affect crop safety. Therefore, the objective of this study was to evaluate the effects of four DRAs, including methylated seed oil (MSO), crop oil concentrate (COC), high surfactant oil concentrate (HSCOC), and high surfactant methylated seed oil (HSMSO), on drift potential and crop safety. Each DRA (0.3% v v^{-1} of spray solution) was applied with dicamba (560 g a.e. ha^{-1}) and glufosinate-P-ammonium (370 g a.i. ha^{-1}) separately, and with a combination of both herbicides. Each solution contained fluorescent tracer at a concentration of 3 g L^{-1}. Applications were performed in a low-speed wind tunnel calibrated to deliver 140 L ha^{-1} using a PSLDMQ2004 nozzle at 276 kPa, with a 4.47 m s^{-1} wind speed. Sensitive soybean (*Glycine max* (L.) Merr.) and 100 cm^2 mylar cards were positioned at downwind distances of 1, 2, 3, 6, 9, and 12 m. Following exposure, plants were relocated to a greenhouse, and biomass reduction was assessed 28 days after application. Mylar cards were washed with a 10% alcohol solution and analyzed to quantify PTSA concentration. Data were analyzed using ANOVA to evaluate the effects of herbicide, adjuvant, and downwind distance, as well as their interactions, on crop safety. Soybean biomass reduction did not differ

among adjuvants within each herbicide solution. For each treatment, ED50 was estimated as the downwind distance (m) at which spray deposition decreased to 50% of the amount released, based on the fitted deposition curve. Dicamba combined with COC had the lowest ED50 (0.98 m ± 0.05 m) among all treatments, indicating reduced drift compared with the others. Dicamba+glufosinate treatments combined with COC had a higher ED50 (1.63± 0.06m). Based on these results, COC may help reduce off-target movement (drift) and not raise in-field crop-response concerns under the conditions tested here. These findings provide additional insight into the effects of drift-reducing agents (DRAs) required by product labels and support a better understanding of their role in drift-mitigation strategies for over-the-top dicamba applications.

15 - Effects of Glufosinate-L and Adjuvant Combinations on Weed Control, Corn Response, and Droplet Spectrum

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Growers face stricter off-target movement mitigation measures to comply with Endangered Species Act regulations. Previous studies suggest that glufosinate-L (Glu-L) may benefit from adding methylated seed oil (MSO) to reduce drift. This study therefore aimed to evaluate the effects of adjuvant combinations on Glu-L drift potential and efficacy. Treatments consisted of Glu-L alone (380 g ai ha^{-1}), mixed with AMS (2.2 kg ha^{-1}) or a non-AMS water conditioner (WC, 0.25% v v^{-1}), and MSO or guar-based drift reduction agent (DRA): MSO 1 (1.7 L ha^{-1}), MSO 2 (0.4 L ha^{-1}), DRA 1 (0.25% v v^{-1}), or DRA 2 (0.75% v v^{-1}). All solutions included acetochlor (1,681 g ai ha^{-1}) and were sprayed with an MR11002 nozzle calibrated to deliver 140 L ha^{-1} at 220 kPa spaced by 50.8 cm. Droplet size spectrum was measured for all treatments using a Sympatec HELOS laser diffraction system inside a low-speed wind tunnel. Volume median diameter (DV50) and percent of droplets less than 141 µm (driftable fines) were analyzed. Additionally, field trials were conducted in North Platte and Mead, Nebraska, to evaluate weed control. Average weed height at application was 12 to 15.2 cm, and carrier volume was 140 L ha^{-1}. Every adjuvant combination provided over 80% *Amaranthus spp.*, above Glu-L alone, except for non-AMS WC + DRA 1 at Mead (69%). At North Platte, non-AMS WC had lower control (<73%) on *Abutilon theophrasti* than other mixes (>76%), but effects varied at Mead, with all mixes above 80%, except Glu-L alone and Glu-L + non-AMS WC + DRA 1. Compared to Glu-L alone, DV50 was increased over 40 µm with MSO and 160 µm with DRAs. Driftable fines were 13.3% for Glu-L and reduced about twofold with non-AMS water conditioner combined with MSO and threefold with AMS + MSO. DRAs were even more effective, decreasing it to under 4%. Minimizing drift losses improves safety for non-target species as well as application quality and effectiveness.

16 - Influence of Nozzle Type and Spray Volume on Droplet Size, Deposition, and Epyrifenacil Efficacy

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Epyrifenacil is a recently released protoporphyrinogen oxidase (PPO)- inhibiting herbicide that offers growers an additional option for managing herbicide-resistant weeds. However, limited information exists on how application parameters affect its spray characteristics, deposition, drift potential, and efficacy. This research aimed to evaluate the effects of nozzle type and carrier volume, adjusted through nozzle orifice size at a constant travel speed, on droplet size distribution, spray deposition, and efficacy of epyrifenacil applied at 20.1 g ai ha^{-1} to control green foxtail (*Setaria viridis* (L.) P. Beauv.), common lambsquarters (*Chenopodium album* L.), Palmer amaranth (*Amaranthus palmeri* S. Watson), and velvetleaf (*Abutilon theophrasti* Medik.). Droplet size distribution was determined for six nozzles (VP, XR, LD, TT, ULD, and AIXR) at three carrier volumes (94 L ha^{-1}, 140 L ha^{-1}, and 188 L ha^{-1}) using three orifice sizes (0.75 L min^{-1}, 1.13 L min^{-1}, and 1.51 L min^{-1}), respectively at 276 kPa in a low-speed wind tunnel equipped with a laser diffraction system. The spray deposition and efficacy trials were assessed using a three-nozzle spray chamber with a fixed traveling velocity of 2.66 m s^{-1} (constant across all orifice sizes employed) and 50.8 cm boom height and nozzle spacing. The spray solution was mixed with a food-grade blue dye (2 g L^{-1}) and sprayed onto kromekote cards at the same height as the weeds, 7.6 to 12.7 cm. At 140 L ha^{-1}, epyrifenacil produced Dv50 values ranging from 236 to 483 µm and driftable fines from 1.88 to 20.69%, depending on nozzle type. Compared with water as the standard, epyrifenacil generally increased Dv50 and reduced driftable fines, although responses varied among nozzles. Increasing carrier volume from 94 to 188 L ha^{-1} by increasing nozzle orifice size generally increased Dv50 and reduced driftable fines at a constant travel speed. Spray coverage generally increased with carrier volume from 94 to 188 L ha^{-1} (0.2 to 0.4 orifice size), ranging from 37% to 74%. At 188 L ha^{-1}, VP provided the highest coverage (74%), while TT and ULD produced the lowest (37%) at 94 L ha^{-1}. The only difference in carrier volumes for efficacy was in foxtail biomass reduction: 93.54, 140.31, and 187.08 L ha^{-1} produced 68.8, 62.5, and 52.9% biomass reduction, respectively. This may be due to green foxtail's narrow, upright architecture, which retains more droplets at higher epyrifenacil concentrations. Although nozzle type and carrier volume influenced spray coverage and droplet size distribution, efficacy followed similar trends across treatments, with distinct responses among weed species. From a practical application standpoint, selecting nozzles that produce coarser droplets may reduce spray drift potential while maintaining effective weed control, although responses may vary among weed species.

17 - Influence of Adjuvants and Wind Speed on Spray Droplet Characteristics in Ground and Aerial Applications

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Aerial pesticide applications, including piloted and unpiloted aircraft, face increasing regulatory requirements in U.S. agriculture. Some spray additives are labeled for use across both low- and high-speed application conditions, highlighting the need to evaluate their effects on spray characteristics, application performance, and drift potential under different operating conditions. Evaluating droplet size distribution across different airspeeds and nozzle orientations is essential for understanding spray characteristics and drift potential under ground, drone, helicopter, and fixed-wing aerial application conditions. Adjuvants containing drift reduction agents may impact droplet spectrum, but their performance may vary with airspeeds. This study evaluated how airspeed, nozzle orientation, and adjuvant selection affect spray droplet size and driftable fines. Two wind tunnels equipped with a laser-diffraction system were used to test five airspeeds corresponding to various applications: 6.7 m s^{-1} (ground), 17.9 m s^{-1} (drone equipment with hydraulic nozzles), 35.8 m s^{-1} (helicopter), and 53.6 and 71.6 m s^{-1} (fixed-wing aerial). A CP11TT-4008 nozzle was evaluated at deflection angles of 0° and 30° and a constant pressure of 276 kPa. Although this nozzle is primarily used for aerial applications, lower airspeeds were included to assess droplet size responses across a broader range of operating conditions. Treatments included water (standard) and four adjuvants: non-ionic surfactant (NIS), high surfactant methylated seed oil (HSMO), deposition aid (DA), and high surfactant oil concentrate (HSOC). All solutions were prepared at a carrier volume of 28 L ha^{-1}, with NIS and DA applied at 0.29 L ha^{-1} and HSMO and HSOC at 0.58 L ha^{-1}. A significant solution by airspeed by nozzle deflection angle interaction was observed. Airspeeds above 35.8 m s^{-1} decreased droplet size (DV0.5) and increased driftable fines across all solutions, particularly at 71.6 m s^{-1} with a 30° nozzle deflection angle. At 6.7 m s^{-1}, all adjuvants reduced driftable fines compared with water. At 0° nozzle deflection, HSOC produced the largest droplets and lowest driftable fines at intermediate airspeeds (17.9 to 53.6 m s^{-1}), reaching a DV0.5 of 685 µm at 35.8 m s^{-1}. In contrast, HSMO produced smaller droplets and more driftable fines than water at higher airspeeds, while DA and NIS showed intermediate responses. At 71.6 m s^{-1}, no adjuvant reduced driftable fines compared with water. Overall, adjuvant effects involved trade-offs between droplet size and drift potential that depended on airspeed and nozzle deflection angle, so ground observations for adjuvant effects may not predict aerial performance.

18 - Influence of Application Time of Day on a Glufosinate-Resistant Waterhemp (Amaranthus tuberculatus) Population.

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Glufosinate use has increased rapidly over the past decade and plays a key role in managing many herbicide resistance weeds, especially in soybean [*Glycine max* (L.) Merr.] production systems. Despite its utility, glufosinate performance is greatly influenced by environmental factors and the size of weeds at application. These inconsistencies in the field raise concerns to whether reduced efficacy is the result of unfavorable application conditions or if there is a shift in population-level sensitivity to glufosinate. Our research objective was to evaluate glufosinate efficacy on a glufosinate-resistant waterhemp (*Amaranthus tuberculatus*) population at varying weed sizes and application times of day. Field experiments were

established as a randomized complete block design with five replications conducted in 2025 and 2026. Herbicide treatments consisted of a nontreated control and low and high rates of glufosinate (330 or 660 g ai ha^{-1}) with 5% v/v AMS. Applications were made when waterhemp across the whole plot averaged 8 to 10 cm (early postemergence) or 15 to 20 cm (late postemergence). In each plot, five individual plants within the target height range were marked. Glufosinate was applied one hour after sunrise, solar noon, and one hour before sunset for both experiments. Control of waterhemp was collected at 14 DAT for the whole-plot and at 28 DAT for individually marked plants. In 2025, the high rate of glufosinate applied early postemergence provided near-complete control of marked waterhemp plants regardless of application timing. However, in 2026 the same application timing resulted in over a 50% progressive reduction in glufosinate efficacy, based on biomass, from the sunrise to sunset application timings. This resulted in only 32% waterhemp survival from the high rate of glufosinate applied in the morning to 92% waterhemp survival for the evening application. At the late postemergence timing, the efficacy for the high rate glufosinate also decreased for the applications later in the day, but to a much lower magnitude than in 2026 for the early postemergence application. Solar radiation accumulation and the sum of temperature (°F) and relative humidity did not fully explain application difference among application timings. However, in 2025 relatively higher humidity persisted later into the day which may have expanded the optimal application window for glufosinate applications on those days compared to the application days in 2026. This research further supports the theory that the expression of waterhemp resistance to glufosinate is variable and dependent on environmental conditions at the time of application.

19 - Spray Drone Platforms vs. Ground Boom Equipment: Waterhemp (Amaranthus tuberculatus) Control and Spray Uniformity Using Multiple Droplet Sizes in Soybean.

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Agricultural spray drone adoption has increased drastically in recent years. However, weed management research using this technology compared with traditional ground sprayers remains limited. Therefore, the objective of this study was to assess waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] control and spray deposition uniformity in soybean [*Glycine max* (L.) Merr.] from multiple spray drone platforms and a ground sprayer across different droplet sizes. A field experiment was conducted in 2025 and 2026 in Farmland, IN, organized in a randomized complete block design with three replications. Treatments consisted of combinations of Fine or Coarse sprays with the DJI Agras T50, Hylio AG230, and EAV J150 spray drone platforms, and the ground-based Capstan PinPoint 3 pulse-width modulation sprayer. The EAV J150 was included only in 2026. Two spray passes with a targeted 9-m swath width were used with the DJI Agras T50, EAV J150, and ground sprayer treatments, whereas three passes with a targeted 6-m swath width were made with the Hylio AG230. Plots were 18 m wide by 73 m long. Spray drone applications were made at 3.7 m above the crop at 28 L ha^{-1} while the ground sprayer operated at 140 L ha^{-1} with the boom positioned 60 cm above the crop. Glufosinate was applied at 881 g ai ha^{-1} along with 5% v/v liquid ammonium sulfate and 600 µg mL^{-1} of 1,3,6,8-pyrenetetrasulfonic acid (PTSA) dye.

Acetate cards were placed on stands every 76 cm (one card between each row, for a total of 25 cards per plot) along a 19-m-long transect, approximately 15 cm above the ground surface and oriented perpendicular to the sprayer travel path to assess spray deposition. Visual waterhemp control and mortality of 15 plants per plot were assessed three weeks after treatment. Spray uniformity varied across spray equipment in both years, with the ground-based sprayer producing more uniform deposition across the swath. Coarse sprays generally resulted in greater deposition than Fine sprays for all spray drone platforms. In both years, the DJI T50 resulted in the most pronounced bell-shaped deposition curves, indicating the effective swath width was narrower than the route spacing set in the controller. In 2025, waterhemp control ranged from 65% with the Hylio AG230 Coarse spray to 75% with the ground Coarse spray. No differences among treatments were observed for mortality. In 2026, no differences among treatments occurred for visual control, whereas mortality ranged from 64% to 95%, with the ground Coarse spray providing the highest mortality. Differences in control and mortality likely resulted from variable deposition patterns among treatments across the swath. Although waterhemp control and mortality varied with spray equipment and droplet size, these findings indicate that spray drones can be effective for weed management. However, swath testing is crucial to determine the effective swath width each spray drone platform can achieve under different setups (e.g., Fine vs. Coarse spray) to reduce the risk of field streaking and, consequently, weed control failures.

20 - Novel Evaluation of Spray Deposition on Weeds from the Verdant Sharpshooter™ Targeted Application System

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The Verdant SharpShooter™ uses cameras and artificial intelligence to detect individual weeds, then swivels straight-stream spray nozzles to ‘aim and apply’ herbicide directly to each target, with manufacturer-reported herbicide savings of up to 99%. However, its performance in soybean production systems remains relatively untested. A field trial was conducted near Atlanta, Indiana in 2026 to evaluate herbicide performance and deposition using the Verdant Sharpshooter™ compared to a conventional broadcast sprayer. The experiment was arranged in a 2x3 factorial randomized complete block design consisting of two herbicide application methods (broadcast- and target-applied) and three herbicide programs for different soybean production systems [conventionally traited (1,261 g ha^{-1} glyphosate + 1,121 g ha^{-1} 2,4-D followed by 510 g ha^{-1} glufosinate-P-ammonium + 1,121 g ha^{-1} 2,4-D), high-oleic (1,261 g ha^{-1} glyphosate + 350 g ha^{-1} fomesafen followed by 1,261 g ha^{-1} glyphosate + 219 g ha^{-1} lactofen), and organic (2,489 g ha^{-1} caprylic acid + 1,694 g ha^{-1} capric acid applied three times)]. Visual assessments of weed control and soybean injury were collected 21 days after application (DAA) and 7 DAA, respectively. To evaluate spray deposition, 0.6 g L^{-1} of PTSA fluorescent tracer dye was added to all tank mixtures. Immediately following the first postemergence application, up to 10 living weeds per plot were clipped and washed to assess on-plant deposition. The collected wash solutions were subsequently analyzed for fluorescent dye concentration using a fluorometer. Due to differences in weed size, all weeds were transported to the laboratory where whole plant leaf area (cm^2) was measured using a leaf area meter. Dye deposition was then standardized by leaf area to quantify deposition per unit of leaf

surface area. All data were analyzed in R 4.5.2, subjected to analysis of variance, and treatment means were separated using post-hoc protected Tukey's HSD tests at a significance level of 0.05. No differences in visual weed control were observed between broadcast- and target-applied application methods at 21 DAA, regardless of herbicide program used, with all treatments providing >90% control. Glyphosate + 2,4-D, glyphosate + fomesafen, and caprylic acid + capric acid broadcast-applied caused 4%, 25%, and 35% soybean injury severity, respectively. Targeted applications of all three herbicide programs mitigated soybean injury severity to 0-7%. Targeted applications averaged 72% spray volume savings when compared to conventional broadcast applications. Broadcast and targeted application methods deposited 60% and 115% of theoretical maximum spray deposition, respectively, indicating targeted applications overdelivered compared to broadcast applications. This research illustrates that equivalent weed control with reduced crop injury can be achieved from the Verdant Sharpshooter™ compared with a conventional broadcast application; however, off-label overdosing may be occurring.

21 - Nozzle Selection and Spray Volume Effects for Liberty Ultra Efficacy on Giant Ragweed (Ambrosia trifida) and Waterhemp (Amaranthus tuberculatus).

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The label for glufosinate-P-ammonium (Liberty Ultra) indicates it should be applied with Medium to Coarse spray droplets and at a minimum of 140 L ha^{-1}. Nozzle type and carrier volume may influence glufosinate-P-ammonium efficacy; however, there is limited literature regarding these application factors with the newest glufosinate formulation. The objective of this study was to evaluate the effects of nozzle type and carrier volume on glufosinate-P-ammonium efficacy. A field experiment was conducted in 2026 at two locations in Indiana: Throckmorton-Purdue Agriculture Center (TPAC) near Lafayette and an on-farm site near Francesville (FRAN). Giant ragweed (*Ambrosia trifida*) and waterhemp (*Amaranthus tuberculatus*) were evaluated at TPAC and FRAN, respectively. At application, waterhemp plants were 15-25 cm tall, and giant ragweed plants were 5-15 cm tall. The experiment was arranged as a randomized complete block design with 19 total treatments replicated four times. All applications were made using an all-terrain vehicle equipped with a 3-meter spray boom and an electric diaphragm pump. Glufosinate-P-ammonium was applied at 370 g a.i. ha^{-1}, and ammonium sulfate was applied at 3.36 kg ha^{-1}. The treatments consisted of six nozzle types [XR, TT, TTJ, AIXR, AITTJ, and TTI (TeeJet Technologies, 11002)] and three carrier volumes (94, 140 and 187 L ha^{-1}), along with a nontreated control. Nozzles selected represent a range of spray droplet sizes from Fine to Extremely Coarse per manufacturer information. Giant ragweed and waterhemp were evaluated for visual control at 7, 14, and 21 days after application (DAA). At 21 DAA, giant ragweed and waterhemp biomass was collected in two 0.25-m^2 quadrats within each plot. Data were analyzed using generalized linear mixed models (ANOVA) in R Studio 2026.1.0.392 using R Version 4.5.2. Results indicated no difference across all treatments for waterhemp visual control (82%) and biomass reduction (71%). At 21 DAA, giant ragweed visual control averaged 96% with no difference across treatments. In contrast, biomass differed among treatments for

giant ragweed, with means ranging from 10 to 42 g m^{-2}, with the lowest mean for AIXR at 94 L ha^{-1} and the highest for TT at 140 L ha^{-1}. Numerically, there is no trend across all nozzle types and carrier volumes. These results suggest across carrier volumes tested (94 to 187 L ha^{-1}) and multiple nozzle types with a range of droplet sizes (Fine to Extremely Coarse), comparable weed control with glufosinate-P-ammonium can be achieved. This would suggest there are other factors that have a greater influence on glufosinate-P-ammonium efficacy than droplet size and carrier volume.

22 - An Enzyme-Based Tank Additive Improves Control of Herbicide-Resistant Palmer Amaranth (*Amaranthus palmeri*) and Waterhemp (*Amaranthus tuberculatus*).

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The use of herbicides to control weeds developed as a standard practice in US agriculture over the past half-century; however, herbicide resistant weed populations are a significant and growing issue that reduces the efficacy of key herbicidal chemistries. A non-herbicidal enzyme-based tank additive, EX (Zymtronix Catalytic Systems), has previously demonstrated increased control of weeds when mixed with glufosinate and glyphosate herbicides under sub-optimal weather and at advanced plant growth stages. Greenhouse trials were conducted in Arkansas in 2025 and Pennsylvania in 2026 to determine whether tank mixes of EX and glyphosate or glufosinate could enhance the efficacy of these herbicides on herbicide-resistant weeds, relative to the herbicides alone. In the 2025 trial, glyphosate- and glufosinate-resistant palmer amaranth (*Amaranthus palmeri* S. Watson) treated with EX and glyphosate (1008 g ha^{-1}) or EX and glufosinate (492 g ha^{-1}) had 45% and 51% greater control, respectively, at 21 days after application compared to those treated with herbicide alone. In the 2026 trial, a glyphosate dose-response was conducted with two characterized glyphosate-resistant waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer) populations with target-site (TSR) or non-target-site (NTSR) resistance mechanisms, compared to two susceptible populations (SUS). Glyphosate was applied to greenhouse plants between 168 to 10,756 g ha^{-1} and compared with the efficacy of identical rates tank-mixed with EX. The glyphosate dose to achieve 50% control (GR50) was quantified at 21 days after application to compare the effect of EX on herbicide efficacy along the range of doses applied. Compared to glyphosate alone, the EX and glyphosate tank mix decreased the GR50 by 5%, 65%, and 23% for TSR, NTSR, and SUS populations. Taken together, these data demonstrate that EX increased control of herbicide-resistant *Amaranthus* species and that the magnitude of increase may be influenced by the mechanism of resistance.

23 - Research Experiences with Drone Herbicide Applications in Michigan Soybean

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The use of unmanned aerial vehicles (UAVs) ‘drones’ for herbicide applications has increased rapidly across the North Central Region due to their ability to make timely applications under challenging field conditions. Field-scale research trials were conducted in Michigan from 2024 through 2026 to evaluate UAV herbicide applications for management of glyphosate-resistant (GR) waterhemp (*Amaranthus tuberculatus*) in soybean. Research objectives were to determine the effects of spray volume and application speed on weed control, compare UAV and ground-rig applications of commonly used POST herbicides, and evaluate season-long weed control from integrated PRE followed by POST herbicide programs. Field experiments were established in commercial soybean fields with GR waterhemp infestations. During 2024 and 2025, glufosinate plus glyphosate was applied using UAVs at multiple spray volumes and application speeds and compared with conventional ground-rig applications. In 2025 and 2026, 2,4-D choline plus glyphosate was evaluated across UAV spray volumes and compared with ground-rig applications. Additional 2026 treatments evaluated glufosinate plus glyphosate applied alone or with S-metolachlor and compared POST-only programs with a PRE herbicide program consisting of metribuzin plus S-metolachlor followed by POST applications of glufosinate plus glyphosate with or without S-metolachlor. Weed control evaluations were conducted throughout the growing season, and UAV applications were compared with ground-rig applications. Across years, increasing spray volume generally improved weed control with UAV applications. In 2024 and 2025, GR waterhemp control from glufosinate plus glyphosate improved as spray volume increased, with 46.8 L ha-1 providing greater control than lower spray volumes regardless of application speed. However, control was often inconsistent and did not always reach commercially acceptable levels. Applications of 2,4-D choline plus glyphosate generally provided greater GR waterhemp control than glufosinate-based programs. POST UAV applications of 2,4-D choline plus glyphosate provided similar waterhemp control compared with a ground rig (1/2 years). In 2026, velvetleaf (*Abutilon theophrasti*) control was consistently greater with ground-rig applications than with UAV applications. Although differences among application methods were observed following POST treatments, end-of-season evaluations in 2026 demonstrated that all effective PRE followed by POST herbicide programs provided excellent control of waterhemp, common lambsquarters (*Chenopodium album*), and common ragweed (*Ambrosia artemisiifolia*) regardless of application method. These results indicate that successful weed management with UAV applications depends on adequate spray volume and the use of effective residual herbicide programs. While UAV applications may not consistently match ground-rig performance for all weed species, particularly velvetleaf, they can provide excellent season-long control of GR waterhemp when integrated into comprehensive weed management programs.

24 - Exploring Ultra-Precise Smart Sprayer (Ecorobotix ARA) for Weed Control in Dry Edible Bean

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Dry bean (*Phaseolus vulgaris* L.) is an important short-season leguminous crop valued for its high protein content. However, slow early growth, and limited registered herbicide options make weed management

challenging in dry bean. The Ecorobotix ARA is an ultra-precision smart sprayer that detects weeds and apply herbicides in real-time to targeted plants, offering the potential to reduce herbicide use and cost savings. A field experiment was conducted in 2026 at the Rosemount Research and Outreach Centre near Rosemount, MN, to evaluate weed control, crop injury, herbicide savings, and dry bean yield using the Ecorobotix ARA precision sprayer. The treatments were arranged in a randomized complete block design with three replications. Treatments consisted of different herbicide application programs, including conventional broadcast applications, targeted applications to weeds using the Ecorobotix ARA, and ARA applications that sprayed all areas except the dry bean at different security zone widths away from dry bean plants. Herbicide programs included imazamox + bentazon, imazamox + bentazon + fomesafen, and saflufenacil + glyphosate, along with a nontreated control. Additional treatments evaluated the effects of 50% dry bean stand reduction. Waterhemp density was lowest in broadcast (0 plants m^{-2}) and targeted ARA applications (1 plants m^{-2}) of imazamox + bentazon + fomesafen compared to the nontreated control (7plants m^{-2}). Giant ragweed density decreased from 5 plants m^{-2} in the nontreated control to ≤ 2 plants m^{-2} in most treatments. Two weeks after POST application, crop injury was 2% or less for all imazamox + bentazon + fomesafen based treatments. Saflufenacil + glyphosate caused 10 to 42% injury, and the targeted application on the 50% reduced stand caused the highest injury (72%). Compared with broadcast application, targeted ARA applications reduced herbicide cost by 43.8% for imazamox + bentazon + fomesafen and by 50.4% for saflufenacil + glyphosate. Dry bean yield with ARA treatments was similar to the broadcast treatments (2,721 to 3,398 kg ha^{-1}), whereas the 50% stand reduction lowered yield to 1,648 kg ha^{-1}. Overall, targeted herbicide application with the Ecorobotix ARA reduced herbicide costs by up to 50% while maintaining weed control and dry bean yields comparable to those achieved with conventional broadcast applications.

25 - Water Conditioners and Glufosinate-Dicamba Tankmixes

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Dicamba has long been utilized for broadleaf weed management in cereal and row crops. The introduction of dicamba tolerant soybean in 2017 resulted in increased usage to aid in controlling glyphosate resistant broadleaf weeds. With glufosinate tolerant corn, soybean and cotton being widely available, glufosinate usage in the US has increased as well, from 0.3 million kg in the US in 2000 to 10.2 million kg in 2023. The vacating of labels for dicamba over the top products in early 2024 removed it as a tool. These labels were reinstated early 2026, with the restriction of no ammonium sulfate (AMS) may be tankmixed. Glufosinate typically performs better when applied with AMS, thus tankmixing dicamba and glufosinate to optimize glufosinate becomes a challenge. A greenhouse study was performed to evaluate products to replace AMS and improve glufosinate performance when tankmixed with dicamba. Water conditioners (containing citric or sulfuric acids and other varying ingredients) were tankmixed with glufosinate and glufosinate plus dicamba. Weeds species included green foxtail, kochia, velvetleaf and common lambsquarter. Visual percent control was recorded 7, 14 and 21 days after treatment (DAT). Dry plant biomass was also recorded 21 DAT. Results show minimal differences among water conditioners tested, and was species dependent. Tankmixes including dicamba and glufosinate often

resulted in greater control than glufosinate alone. The absence of AMS in dicamba + glufosinate tankmix was typically not inferior to glufosinate alone with any water conditioner (including AMS).

26 - Spray water pH: Does it make a difference in weed control?

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Water quality can influence herbicide efficacy, particularly when dissolved cations interact with herbicides or water pH affects herbicide stability. Although pH-adjusting adjuvants and water conditioners are commonly used to improve spray solution characteristics, their contribution to weed control may vary depending on water chemistry, environmental conditions, and herbicide program effectiveness. Field experiments were conducted in 2025 and 2026 in Rochester, Minnesota, to evaluate the influence of a water pH-adjusting adjuvant, AlpHa Shot, on chemical control of waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer) in corn. Each treatment consisted of a tank mix including glyphosate + mesotrione + S-metolachlor + bicyclopyrone, and atrazine, followed by POST application of glyphosate + mesotrione + S-metolachlor + bicyclopyrone at either a half or full rate. AlpHa Shot was applied under two timing scenarios: (1) 6 d prior to spraying and (2) the day of herbicide application. Waterhemp control was visually assessed at 24 and 112 d after planting (DAP). In 2025, the presence of the pH adjuster improved waterhemp control regardless of application timing. At 24 DAP, control increased by 10% with the addition of the pH adjuster, while control at 112 DAP improved by 7%. In contrast, observations from 2026 indicated excellent waterhemp control across treatments, with at least 94% control by 24 DAP and complete control by 112 DAP. Under these conditions, the addition of the pH adjuster did not appear to provide a substantial improvement over the herbicide program alone. These results highlight potential year-to-year variability in the contribution of water pH-adjusting adjuvants to herbicide performance and suggest that their benefits may depend on environmental conditions and the overall effectiveness of the herbicide program.

27 - Effect of Saflufenacil Spot-spray Application at Different Growth Stages and Spray Coverage Levels on Soybean Yield

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[1]Iowa State University

Precision application systems are increasingly being adopted to target weedy areas within fields aiming to reduce herbicide use relative to broadcast applications. Glyphosate and glufosinate are used in these systems for their broad-spectrum activity and compatibility with commercially available herbicide-tolerant soybean varieties. However, widespread glyphosate resistance and emerging reports of glufosinate resistance highlight the need to investigate additional herbicide options. A field experiment was conducted at Curtiss Farm in Ames, IA, in 2026 to evaluate the effects of application timing and proportion of plot area treated with a protoporphyrinogen oxidase (PPO/Group 14) non-selective herbicide on soybean yield. Treatments were arranged in a 3 x 2 factorial design consisting of three

soybean growth stage at application (V4, V6, and R3) and four proportion of plot area treated (10%, 30%, 50%, and 70%), plus a nontreated control, with four replications. To simulate the effects of a non-selective herbicide on soybean, saflufenacil was applied at 38 g ai ha^{-1}, methylated seed oil (MSO) at 1% v v^{-1}, and ammonium sulfate (AMS) at 10 g L^{-1}. Applications were made using a two-nozzle handheld CO_2-pressurized backpack sprayer calibrated to deliver 140 L ha^{-1}. Treatment areas within each plot were marked with flags to achieve the designated proportions of area treated. All plots were maintained weed-free throughout the study to isolate the effects of herbicide exposure on soybean yield. Data were analyzed in SAS using the PROC GLIMMIX procedure, and means were separated using Tukey's test at $\alpha = 0.05$. Yield results were unavailable at the time of abstract submission because adverse weather conditions had delayed harvest.

28 - Effects of Nozzle Type and Imazamox - Auxin Herbicide Mixtures on Droplet Characteristics, Spray Coverage, and Canopy Penetration

Jeremie Kouame[1], Taylor Lambert[1], Atong Akom[1], Patrick Geier[1], Sarah Ganske[1], Augustine Obour[1], Gaurav Jha[1], Jeanne Falk-Jones[1], Sarah Sexton-Bowser[1], Tommy Butts[2]

[1]Kansas State University, [2]Purdue University

Integrated weed management strategies that combine crop competitiveness, application technology, and herbicide programs are needed for Palmer amaranth [*Amaranthus palmeri* S. Watson] and kochia [Bassia scoparia (L.) A. J. Scott] control in no-till dryland production systems of western Kansas. Nozzle selection is crucial for ensuring adequate herbicide deposition and canopy penetration while minimizing off-target movement. Field experiments were conducted during the summers of 2025 and 2026 at the Kansas State University Agricultural Research Center (Hays, KS) and the Southwest Research-Extension Center (Garden City, KS) to evaluate the impact of row spacing, nozzle type, and postemergence herbicide mixtures on canopy penetration and spray deposition in igrowth grain sorghum [*Sorghum bicolor* (L.) Moench]. A 3-factor treatment structure, arranged in a split-plot design with four replications, was implemented at each site. The main plots consisted of two row spacings (38 cm and 76 cm), while the subplots combined two nozzle types [single-fan (AIXR) and dual-fan (AITTJ60)] with six postemergence herbicide mixtures. The herbicide mixtures included imazamox (52 g ha^{-1}), imazamox + fluroxypyr (52 + 157 g ha-1), imazamox + 2,4-D (52 + 532 g ha-1), imazamox + dicamba (52 + 280 g ha-1), bromoxynil + fluroxypyr +pyrasulfotole (202 + 84 + 36 g ha-1), atrazine + bromoxynil + dicamba (560 + 70 +140 g ha-1). Water-sensitive cards were placed above and below the grain sorghum canopy to quantify spray deposition and canopy penetration. A droplet size experiment evaluated the droplet size and velocity of each nozzle type used in the field experiment with imazamox and each auxin herbicide, alone or in mixtures. Results showed that nozzle effects on the number of spray deposits cm^{-2} depended on row spacing, herbicide treatment, and canopy position. At 15-inch spacing, AITTJ60 produced significantly greater deposits cm^{-2} than AIXR for bromoxynil + fluroxypyr + pyrasulfotole at the top canopy position ($P = 0.0124$) and imazamox at the bottom canopy position ($P < 0.0001$). No significant differences between nozzle types were detected for the remaining herbicide and canopy-position combinations at 15-inch spacing or for any combination at 30-inch spacing. The number of spray deposits cm^{-2} also differed

between above- and below-canopy positions depending on row spacing, nozzle type, and herbicide treatment. AITTJ60 nozzle consistently produced coarser droplets ($Dv_{0.5}$ between 292 and 411 µm) than the AIXR nozzle ($Dv_{0.5}$ between 242 and 299 µm). In conclusion, the AITTJ60 nozzle improved deposits while producing the largest droplet size, reducing spray-drift potential (7 and 11% driftable fines) compared to the AIXR nozzle (13 to 19% driftable fines). This dual-fan nozzle may be a better option for herbicide applications when off-target movement is a concern and when improved canopy penetration is needed under narrow-row spacing conditions.

29 - What's New with CPDA?

Gregory Dahl[1]

[1]Council of Producers & Distributors of Agrotechnology

For more than thirty years, the Council of Producers and Distributors of Agrotechnology, commonly known as CPDA, has been recognized as the premier advocate for formulators, distributors, and manufacturers of agrotechnology in the United States. The CPDA community is a nationwide network of basic inert manufacturers, adjuvant formulators, distributors and retailers, including crop protection product marketing companies and affiliates dedicated to addressing regulatory issues and advocating for the industry at the federal and state level. Eighty percent of CPDA membership currently represents 80% of U.S. inert ingredients used in adjuvants and crop protection products. Members continue to enhance their knowledge through conferences, workshops, training seminars, and collaboration.

To encourage product stewardship, the CPDA Adjuvant Certification Program was developed to ensure that growers certified products meet the claims indicated on the label, and the ingredients used in the product meet EPA regulations for crop protection tank-mix partners. Certified products must meet a uniform set of standards, including 17 benchmarks that have been established in accordance with ASTM International Standards. Today, there are more than 220 CPDA certified adjuvant products and 480 EPA registered crop protection products recommending the use of CPDA Certified Adjuvants.

CPDA and the Agricultural Retailers Association, ASA, have been hosting “Adjuvant Advantage for the Sales Agronomist” Webinars for the past several seasons. CPDA and ARA are conducting their fifth season of these webinars. The webinars can be viewed by anyone for free, but registration is required. Certified Crop Advisors are awarded one CEU in Integrated Pest Management for attending. Previous Webinars can be viewed at the CPDA Website.

CPDA has been involved in many aspects of the Endangered Species Act, ESA. CPDA members have been part of several ESA tours hosted by the National Alliance of Independent Crop Consultants, NAICC, Weed Science Society of America, WSSA, representatives and with representatives of the U. S. Environmental Protection Agency, EPA, U. S. Fish and Wildlife Service and other agencies and organizations. CPDA representatives were able to recommend the use of certain Drift Reduction Adjuvants, DRA’s, to help reduce buffer zones and mitigate off-target movement of pesticides. CPDA has also been educating applicators and promoting protection of endangered species from pesticides.

Today, our industry is faced with ever-changing policies and information about crop protection products and the technologies that are developed to enhance the performance of crop protection products and biorationals. Through its strong working relationships with Legislators, Federal and State regulatory

agencies, the Weed Science Societies, and other organizations, CPDA strives to educate members, regulators, academics, and consumers about this critical sector of agriculture.

30 - Putting Precision Lasers to Work: A New Tool for Integrated Weed Management in Sugar Beet

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[1]University of Minnesota, [2]Beet Sugar Development Foundation

Waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] and common lambsquarters (*Chenopodium album* L.) are the most troublesome weeds in sugar beet (*Beta vulgaris* L.) production in Minnesota. Moreover, herbicide resistance in some of the populations has left growers dependent on layered soil-residual herbicides, which perform poorly with excessive or insufficient precipitation. LaserWeeder™ (by Carbon Robotics) is a camera-guided weed management tool that kills small weed seedlings with a directed thermal laser energy, adding a postemergence (POST) tactic that does not depend on herbicide application. Strip trials were conducted in 2026 in two grower fields in Kandiyohi and Chippewa Counties, MN (referred to as ‘Field A’ and ‘Field B’, respectively), to determine whether a precision laser weeder could improve weed management in sugar beet by replacing one POST herbicide application or complementing the herbicide program. All strips received ethofumesate (6 pt/A) after planting, followed by (fb) glyphosate plus a soil-residual layby herbicide. Treatments were (1) base program alone; (2) base fb a second glyphosate plus layby application; (3) base fb the second application fb one laser pass; and (4) base fb two laser passes 7 to 12 d apart. At 3 weeks after the second pass of the laser weeder, broadleaf weed density in the base program alone was 400 and 533 plants 100 m^{-2} at sites A and B. A second herbicide application, one or two laser passes, or their combination reduced weed density to less than 133 plants 100 m^{-2}. Similarly, biomass was reduced from 5,360 and 7,870 g 100 m^{-2} in the base program alone to less than 413 g 100 m^{-2} in the other treatments. Two laser passes without the second herbicide application reduced density and biomass similarly to two herbicide applications. Root yield (69,100 to 93,400 kg ha^{-1}) and recoverable sucrose (8,740 to 10,650 kg ha^{-1}) were similar across the treatments and were different at both sites. Overall, these findings suggest that two laser weeding passes could replace a second POST herbicide application without compromising sugar beet yield, offering a potential strategy to reduce herbicide use while maintaining effective weed management.

31 - Assessing Weed Control, Crop Development, and Yield with ARA Ultra-High-Precision Smart Sprayer in Wisconsin Non-GMO Corn and Soybean Systems

Nikola Arsenijevic[1], Dan Smith[1], Ryan DeWerff[1], Katerina Lee[2], Rodrigo Werle[1]

[1]University of Wisconsin-Madison, [2]Ecorobotix SA

Assessing Weed Control, Crop Development, and Yield with ARA Ultra-High-Precision Smart Sprayer in Wisconsin Non-GMO Corn and Soybean Systems

The impact of ultra-high-precision spot spraying on herbicide savings, weed control, crop safety, and yield in North Central US row crops warrants investigation. In 2026, the Ecorobotix ARA spot sprayer was compared with broadcast postemergence (POST) herbicide application in non-GMO corn (*Zea mays* L.) and non-GMO soybean [*Glycine max* (L.) Merr.] at three and four Wisconsin locations, respectively. All sites received a preemergence (PRE) herbicide at planting, selected by each farm manager. The corn POST program was nicosulfuron (34 g ai ha^{-1}) + bromoxynil (280 g ae ha^{-1}) + mesotrione (105 g ai ha^{-1}), and soybean received lactofen (219 g ai ha^{-1}) + clethodim (102 g ai ha^{-1}) + bentazon (701 g ai ha^{-1}). Both mixtures included crop oil concentrate (1% v/v) and ammonium sulfate (2.24 kg ha^{-1}). Treatments were arranged as six adjacent plot pairs per location. Weed density at POST and 28 days after treatment (DAT), weed cover 28 DAT, crop injury 14 DAT, crop height 28 DAT, and grain yield were compared using paired t-tests with Benjamini-Hochberg-adjusted q-values. Because the systems were calibrated differently (ARA 200 L ha^{-1} on targeted areas; broadcast 145 L ha^{-1}), herbicide savings were calculated as the percentage of spray solution saved relative to ARA treating the entire plot (0% savings). In corn, ARA treated an estimated 37-40% of the plot area, saving 60-63%. In soybean, savings were 76-99% at three locations but lower (24%) at Janesville due to lack of early season rainfall for PRE activation and adequate crop establishment accompanied by extreme high giant ragweed (*Ambrosia trifida* L.) density. Soybean area treated increased with weed density at application (Spearman $\rho = 0.90$, $P < 0.001$). Spot spraying improved soybean crop safety, reducing injury at 14 DAT by 7 to 37% percentage points and increasing height at all locations by 7 to 12 cm. In corn, injury decreased at two locations but increased at Arlington, while spot-sprayed corn was 7 to 16 cm taller at all locations. Soybean weed density and cover at 28 DAT did not differ between treatments at all locations. In Brooklyn corn, weed density at 28 DAT, predominantly waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer], was 14-fold higher with spot spraying ($q < 0.001$), likely due to waterhemp emerging after application. Preliminary yield results indicate 7% higher yield with spot spraying in Arlington soybean ($q = 0.005$), with no differences in Brooklyn soybean or Arlington and Brooklyn corn. Janesville soybean was not harvested due to severe late-season giant ragweed infestation; Lancaster yields will be presented at the conference. Overall, ARA saved herbicide at all locations and reduced crop injury in six of seven crop-location combinations, yielding taller crops at 28 DAT. However, spot rather than broadcast application of foliar herbicides with soil residual activity prevented them from suppressing new weed cohorts, particularly waterhemp in corn at Brooklyn, emerging after application. These findings show that ultra-precision spot spraying can reduce herbicide use and improve crop safety, although weed control may depend on weed pressure and composition, species-specific emergence patterns, and crop stage at application.

32 - Using Image-Based Phenotyping to Assess Herbicide Drift: A Case Study of Glyphosate on Bur Oak Saplings

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[1]University of Nebraska - Lincoln

Off-target herbicide movement can expose sensitive non-target vegetation, including woody plants in nurseries and managed landscapes, to sub-label herbicide doses that may cause injury and affect plant growth. Assessments of herbicide-induced injury and growth responses commonly rely on visual ratings and destructive measurements. However, destructive sampling prevents continued monitoring of plant growth, injury, and recovery over time. This study evaluated the potential of image-based phenotyping as a nondestructive approach for quantifying herbicide drift effects, using bur oak (*Quercus macrocarpa* Michx.) exposure to glyphosate as a case study. One-year-old saplings were treated with glyphosate at rates of 0, 8.4, 42, 84, 168, and 252 g ae ha^{-1}. Applications were performed with a CO_2-powered backpack sprayer equipped with four AIXR 11002 flat-fan nozzles, calibrated to deliver 140 L ha^{-1} at 275 kPa. Plants were imaged weekly at the Nebraska Innovation Campus Greenhouse using multi-angle visible RGB, infrared, fluorescence, and hyperspectral imaging. Visible RGB images were analyzed using a custom Shiny application developed to segment leaves from stems and branches and quantify projected plant area. For 18 saplings destructively harvested immediately after imaging, pixel counts were averaged across camera angles and related to measured leaf area and fresh and dry biomass using regression. Image-derived traits from the Shiny application were strongly associated with destructive measurements. Total fresh biomass showed the strongest relationship when leaf and stem pixels were modeled separately ($R^2 = 0.951$), followed by total dry biomass ($R^2 = 0.942$). Leaf area was related to leaf pixels with an R^2 of 0.861. These findings highlight the potential of multi-angle phenotyping to assess growth and biomass responses in bur oak saplings exposed to sub-label herbicide doses. Ongoing analysis of image-derived traits, including projected area and estimated biomass, may provide a nondestructive approach to monitoring injury and growth responses following off-target herbicide exposure.

Student Poster Contest – Horticulture, Specialty Crops, Turf and Ornamentals

33 - Influence of Maleic Hydrazide and Mesotrione on Daughter Tuber Production and Subsequent Volunteer Emergence

Nathan Welch[1], Erin Burns[1]

[1]Michigan State University

Potatoes (*Solanum tuberosum* L.) left behind at harvest, combined with warm winter temperatures, result in volunteer potatoes which become problematic weeds. Variable emergence patterns, large energy stores, and daughter tuber production reduces effectiveness of conventional herbicides. Maleic hydrazide (MH), a plant growth regulator historically used to inhibit sprouting in potato storage, may offer potential as a management tool by preventing daughter tuber formation and emergence therefore reducing volunteer pressure in subsequent growing seasons. Given the efficacy of mesotrione on volunteer potatoes and the potential of MH to inhibit tuber development, their combined use was evaluated as a novel strategy to reduce volunteer potato competition, daughter tuber production, and subsequent emergence in rotational cropping systems. Therefore, this study was conducted in 2025-2026 at East Lansing, MI, utilizing a randomized complete block design with four replications. To simulate volunteers, potatoes were spread

(3.25 tubers m^{-2}) and incorporated with a disk. Treatments were arranged factorially and included four application timings (32, 40, 48, and 56 cm plants) and three herbicide treatments: mesotrione alone (MESO), mesotrione plus maleic hydrazide (MESO + MH), and a non-treated control (NTC). Data collection included visual control ratings (14, 21, and 28 days after application-DAA), daughter tuber production, sprouting probability, and plants emerged in the subsequent spring. All data were analyzed using linear mixed-effects models in R and treatment means were separated using Tukey’s HSD; except daughter tuber sprouting probability which was analyzed using a generalized linear model with binomial error distribution and logit link function. Visual control was affected by application timing ($p<0.0001$), with injury declining as volunteer potato height increased at application. The 40 cm application timing produced 22% less daughter tubers than the 48 cm timing ($p=0.043$). Additionally, the MESO treatment reduced daughter tubers production by 20% relative to the NTC ($p<0.0001$). Daughter tuber weight per plant was affected by treatment ($p<0.0001$), where NTC produced 47% greater tuber weight than treated mother plants. Daughter tuber sprouting probability was affected by the herbicide treatment by application timing interaction ($p<0.0001$). No reductions in sprouting probability were observed at the 32 or 40 cm application timings, where sprouting remained above 93% across treatments. However, at 48 cm, sprouting probability was reduced to 67 and 73% by MESO+MH and MESO, respectively, and at 56 cm, MESO+MH reduced sprouting probability by 15% relative to the 98% probability of the NTC. Spring emergence of daughter tubers left to overwinter was affected by the herbicide treatment by application timing interactions ($p<0.0001$), either treatment at 48 cm or MESO at 56 cm reduced emergence by 59%. The greatest suppression occurred when MESO+MH was applied at 56 cm, reducing emergence by 79% relative to NTC. Overall, there were no strong differences between MESO or MESO+MH for visual control or daughter tuber production. Conversely, the addition of maleic hydrazide provided benefit to mesotrione in reducing sprouting probability, and number of plants emerged in the subsequent spring when applied to mother plants at the later application timings.

34 - Beet the Weeds: AI-Targeted Herbicide Applications in Garden Beet with Verdant Robotics Sharpshooter.

Marian Hollenbeck[1], Luke Mackara[1], Chad Yagow[2], Beth Ferguson[1], Lynn Sosnoskie[3], Thierry Besançon[1]

[1]Rutgers University, [2]Verdant Robotics, [3]Cornell

Herbicides are important for weed management in vegetable crops, but their use can increase production costs, cause crop injury, and select for resistant weeds. Vision-guided targeted sprayers, such as the Verdant Robotics Sharpshooter™, may reduce herbicide inputs while maintaining weed control. A field trial was established June 25, 2026, at the Rutgers Agricultural Research and Extension Center in Bridgeton, NJ, on a Downer loamy sand, using garden beet (*Beta vulgaris* L.) ‘Jolie’. A randomized complete block design included four replications and six treatments: nontreated control (NTC); *S*-metolachlor preemergence (PRE) alone; PRE followed by broadcast clopyralid + phenmedipham (Broad); and PRE followed by targeted clopyralid + phenmedipham (SpotConA), carfentrazone-ethyl (SpotConB), or caprylic + capric acid (SpotOrg). *S*-metolachlor was applied PRE at planting on June 25 at 726 g ai ha^{-1}. Two postemergence (POST) herbicide applications were made on July 14 (S1) and 29 (S2), corresponding to 19 and 34 days after planting, respectively. Clopyralid + phenmedipham were applied at 105 g ae ha^{-1} + 274 g ai ha^{-1}, carfentrazone-ethyl at 35 g ai ha^{-1}, and caprylic + capric acid at 6% v/v.

Assessments included weed density, cover, biomass, crop injury, and marketable beet production. At seven days after the first POST application (7 DAS1), weed density averaged 9 weeds m^{-2} in Broad and SpotConA, compared with 5 and 2 weeds m^{-2} in SpotOrg and SpotConB, respectively. At harvest (36 DAS2), Broad had significantly lower weed cover (15%) and fresh biomass (61 g m^{-2}) than SpotConA (29% and 151 g m^{-2}), despite identical herbicides and rates. Weed cover averaged 22% with PRE alone and SpotConB, 25% with SpotOrg, and 100% in the NTC. Corresponding biomass was 67, 160, 228, and 300 g m^{-2}, respectively. Broadleaf biomass remained low across herbicide treatments (6 to 21 g m^{-2}), whereas grass escapes contributed substantially to biomass in targeted treatments. Crop injury varied among POST programs. At 7 DAS1, SpotConB and SpotOrg caused 39% and 24% necrosis, respectively, whereas Broad and SpotConA caused minimal injury. At 7 DAS1, stunting averaged 40% and 16% with SpotConB and SpotOrg, compared with 7% and 1% for Broad and SpotConA, respectively. Following the second POST application, SpotConB and SpotOrg caused 11% and 10% necrosis at 7 DAS2, respectively, while stunting averaged 17% and 14% at 14 DAS2. At harvest, marketable beet weight ranged from 682 to 865 g m^{-1} of row among herbicide treatments, compared with 192 g m^{-1} in the NTC. Marketable proportions (63-76%) significantly exceeded the NTC (32%), with no significant differences among herbicide treatments ($\alpha = 0.05$). Targeted clopyralid + phenmedipham maintained marketable production comparable to broadcast spraying despite greater late-season weed pressure. These findings highlight the importance of herbicide selection and spray placement; further research is needed to quantify potential herbicide savings.

35 - Responses of Garden Beet Varieties to S-metolachlor and Ethofumesate.

Tong Zhen[1], Luke Mackara[1], Jane Petzoldt[2], Michael Bohrer[2], Lynn Sosnoskie[2], Thierry Besançon[1]

[1]Rutgers University, [2]Cornell University

Preemergence herbicides are important tools for weed management in garden beet (*Beta vulgaris* L.) production in New York and New Jersey. However, growers have reported delayed crop emergence and stunting following applications of S-metolachlor and ethofumesate. Field trials conducted in New Jersey (NJ) and New York (NY) in 2026 evaluated weed suppression, crop establishment, and root yield of ten garden beet varieties under three herbicide programs: an untreated control, S-metolachlor alone (0.72 kg ai ha^{-1}), and S-metolachlor (0.72 kg ai ha^{-1}) plus ethofumesate (1.05 kg ai ha^{-1} in NJ and 2.1 kg ai ha^{-1} in NY). Trials were established on Chillum silt loam in NJ and predominantly Lima loam in NY. Randomized split-plot designs assigned herbicide programs to main plots and varieties to subplots, with four blocks in NJ and three in NY. Seeding densities were 23 and 56 seeds m^{-1} of row in NJ and NY, respectively. Beet stand counts were recorded at 14 and 31 days after application in NJ and at 13 and 32 days in NY. Weed biomass and total and marketable harvested root counts and fresh weights were measured at 48 days after planting in NJ and 76-90 days after planting in NY. Herbicide programs significantly affected final weed biomass at both locations. In NJ, herbicide programs also significantly affected total harvested root counts, total root fresh weight, and marketable root fresh weight; these effects were not significant in NY. In NJ, S-metolachlor plus ethofumesate reduced harvested root counts by 37% relative to the untreated control. Nevertheless, total root fresh weight increased by 69% with S-metolachlor alone and 81% with S-metolachlor plus ethofumesate. Marketable root fresh weight

increased by 83% and 65%, respectively, with no significant difference between the two herbicide programs. In NY, Red Cloud produced significantly greater marketable root fresh weight than Ruby Queen and Merlin, while Bresko exceeded Merlin, averaged across herbicide programs. The herbicide-by-variety interaction was not significant, providing insufficient evidence that varietal responses differed among programs. In NJ, significant herbicide-by-variety interactions occurred for beet stand counts and harvested root counts. Relative to untreated controls, S-metolachlor plus ethofumesate reduced harvested root counts by approximately 70% in Red Ace, 59% in Jolie, and 50% in Scarlett, compared with 11% in Ruby Queen. Bresko maintained similar harvested root counts across treatments. These findings suggest a potential tradeoff between weed suppression and crop safety, as increased root fresh weight coincided with reduced harvested root counts in NJ. Differences between locations may reflect environmental conditions and management practices. Herbicide programs should therefore be evaluated for both stand preservation and marketable yield, with consideration of variety and growing conditions.

36 - Response of Velvetleaf (*Abutilon theophrasti*) and Oats (*Avena sativa*) to POST Herbicides plus Peppermint (*Mentha* x *piperita*) Oil.

Jared Ponce[1], Stephen Meyers[1], Nicolle Salamanca[1]

[1]Purdue University

Non-ionic surfactants and crop oils are commonly used agricultural adjuvants to improve herbicide performance by enhancing spray spreading, wetting, and uptake. This study evaluated mint oil as a potential alternative to non-ionic surfactant and crop oil concentrate in herbicide applications to cereal oat (*Avena sativa*) and velvetleaf (*Abutilon theophrasti*). Five treatments were evaluated for each species: herbicide alone (untreated adjuvant control), crop oil concentrate (COC) at 1% v/v, mint oil at 1% v/v combined with Tween 20 at 1% v/v as an emulsifier, nonionic surfactant (NIS) at 0.25% v/v, and an untreated control. The experiment was conducted in 2026 under greenhouse conditions at Purdue University, with five replicates per treatment across two experimental runs. Clethodim was applied to oats at 210 g ai ha^{-1}, while carfentrazone was applied to velvetleaf at 34.7 g ai ha^{-1}. Visual injury was assessed at 1, 3, 7, and 14 days after treatment (DAT). In oats, no visible injury was observed at 1 and 3 DAT, while mean injury ranged from 79% to 87% at 7 DAT, with no significant treatment differences (P = 0.6483). By 14 DAT, all treatments reached 100% injury. Velvetleaf exhibited a faster response, with mean injury from carfentrazone reaching 98% by 3 DAT and 100% by 14 DAT across all treatments. However, statistical limitations prevented reliable comparisons among velvetleaf treatments. Overall, both weed species exhibited substantial injury following treatment. However, given that even treatments with no adjuvant provided complete control, we could not establish whether mint oil performed differently from commercially available adjuvant standards.

37 - Peppermint (*Mentha × piperita*) Response to Post-Harvest Applications of Tiafenacil and Saflufenacil Under Greenhouse Conditions.

Nicolle Salamanca[1], Stephen Meyers[1], Jared Ponce[1]

[1]Purdue University

Peppermint (*Mentha × piperita* L.) is a high-value essential oil crop with limited herbicides for weed control. The period immediately after harvest, when the canopy has been removed and regrowth is just beginning, is a critical window for weed management, but the tolerance of peppermint to protoporphyrinogen oxidase (PPO)-inhibiting herbicides applied at this stage remains unclear. A greenhouse study was conducted at the Purdue University Horticulture Plant Growth Facility, West Lafayette, IN to evaluate the response of peppermint to tiafenacil and saflufenacil applied at 0, 10 or 20 days after a simulated harvest (DAH). ‘Redefined Murray Mitcham’ peppermint was established from shoot tip cuttings and cut at the substrate surface at 8 weeks after planting. Each herbicide was applied at 50 and 100 g ai ha^{-1} at each timing, and a nontreated control was included for each timing. The experiment design was a randomized complete block with three replications. Visible injury was rated at 1, 2, 4, and 6 weeks after treatment (WAT) and aboveground dry weight was determined at 6 WAT. Dry weight was expressed as a percentage of the nontreated control. Injury differed among treatments at 1 and 2 WAT ($P < 0.001$) and was greatest with tiafenacil, reaching 95% at 1 WAT (100 g ha^{-1} applied 0 DAH) and 88% at 2 WAT (50 g ha^{-1} applied 20 DAH), compared with a maximum of 53% (100 g ha^{-1} applied 10 DAH or 50 g ha^{-1} applied 20 DAH) with saflufenacil. By 4 WAT injury did not exceed 37% and by 6 WAT injury did not differ among treatments ($P = 0.146$; maximum 27%). Dry weight was reduced by tiafenacil at 50 g ha^{-1} applied 10 DAH (60%), 100 g ha^{-1} applied 10 DAH (57%), and 100 g ha^{-1} applied 0 DAH (57%), whereas saflufenacil reduced dry weight by 7 to 31%. These results indicate that peppermint recovers visually from post-harvest applications of both herbicides but that biomass losses can persist after injury symptoms disappear, especially with tiafenacil. Saflufenacil appears safer than tiafenacil under these conditions.

38 - Specialty Crop Safety Following Simulated Bioherbicide Exposure

Rasmita Mainali[1], Ana Laura Camachos de Oliveira[1], Breno Rodrigues[1], Gustavo Fujihara[1], Jeff Golus[1], Kasey Schroeder[1], Milos Zaric[1]

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Weed control in specialty crop production systems is challenging due to high labor costs and limited registered herbicides and application guidance. Plant-based bioherbicides offer an alternative approach to weed management. However, research on the effects of non-selective bioherbicides on crop safety remains limited. A dose-response study will help to identify the crop-safety threshold. This greenhouse study aimed to determine the dose response of three selected specialty crops, *Zea mays* var. *Saccharata* (sweet corn), *Amaranthus tricolor* (Leafy amaranth), *Spinacia oleracea* (spinach) to various doses of

commonly used conventional and bio-based herbicides. Six bioherbicides were tested: ammonium nonanoate (13 % v v^{-1}), caprylic and capric acids (9% v v^{-1}), eugenol (3.51 L ha^{-1}), clove and cinnamon oils (5% v v^{-1}), d-limonene (10% v v^{-1}), and pelargonic acid (10% v v^{-1}). Bioherbicides were applied at doses of 0, 0.1, 0.25, 0.5, 1, and 2× rates in a single-nozzle spray chamber equipped with a TP4003E nozzle, calibrated to deliver 400 L ha^{-1} at 276 kPa with a 38.1 cm boom height and traveling velocity of 1.82 m s^{-1}. Spraying occurred when corn was at the V3 growth stage, and leafy amaranth and spinach were at the four-true-leaf stage. The experiment was arranged as a randomized complete block design (RCBD) with five replications and two experimental runs. Fifteen days after treatment, aboveground biomass was harvested and oven-dried at 52 °C to a constant mass, after which dry weights were recorded. Overall, spinach, leafy amaranth, and sweet corn showed sensitivity ranging from high to low, respectively, to most of the tested solutions. The results indicate that pelargonic acid, capric and caprylic acid, and ammonium nonanoate required doses between 0.15 and 0.2x to achieve a 10% biomass reduction in leafy amaranth and spinach, suggesting these crops were more sensitive to these species even at lower doses. d-limonene was less effective for all crop species, requiring high doses (0.68 to 1.15x) to achieve 10% and 15% biomass reduction. Less than 50% biomass reduction was observed in sweet corn at 1x rate, except for capric and caprylic acid (75%). These findings may inform recommendations on how exposure to some bioherbicides may affect crops and underscore the importance of considering drift potential during targeted spray application, especially for non-selective products.

39 - Effects of Paclobutrazol, Phosphorus, and Rootzone pH on Creeping Bentgrass (*Agrostis stolonifera*)-Annual Bluegrass (*Poa annua*) Putting Green Population Dynamics

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Annual bluegrass (*Poa annua*; ABG) commonly encroaches into creeping bentgrass (*Agrostis stolonifera* L.; CBG) putting green, thereby disrupting golf ball roll and the aesthetics of the turf. Paclobutrazol is used to suppress ABG growth in CBG putting systems. A previous greenhouse study suggested that under acidic soil pH (~5.6) and low soil phosphorous (4-6 mg/kg), CBG cover increased by 76% compared to 15% in ABG. However, it remains unclear how a combination of paclobutrazol, rootzone pH and supplement phosphorus would increase CBG encroachment into ABG putting green. A field experiment was conducted beginning in 2025 on a >10-year-old ABG putting green at Rutgers Hort Farm No. 2. We had a three (2 × 2 × 2) factorial design of PGR (paclobutrazol vs. trinexapac-ethyl; TE), P (low vs adequate), and pH (acidic vs neutral). Five gypsum applications (1265 kg ha^{-1}) were made to acidic treatments to supply calcium, while annual calcitic lime (3664 kg ha^{-1}) was applied to maintain neutral pH. Other treatment applications included monthly phosphorus (20 kg P_2O_5 ha^{-1}) during the growing season and paclobutrazol (50 g ha^{-1}) every 300 GDD days from May to October. The rootzone, specifically the mat layer, was sampled in May and November to assess rootzone pH and nutrients. The rootzone pH averaged 5.4 pH for acidic treatments and 6.6 for neutral treatments. Rootzone Ca averaged 543 mg/kg for acidic pH and 963 mg/kg for neutral treatments, indicating Ca concentration levels from gypsum and lime applications, respectively. Rootzone P ranged from 42 to 46 mg/kg and was not affected

by P supplement. Eight 'Oakley' CBG plugs were harvested from a putting green and top 1 cm planted into the ABG in June 2025. Fourteen months after planting, bentgrass cover was measured using a grid intersect, where each plug measured 20 intersects at planting. Turf quality, NDVI, and clipping yield of ABG were measured monthly including clipping nutrients. Results revealed that main effects of acidic pH, low P, and paclobutrazol applications independently increased CBG encroachment by 21, 22, and 21 intersects compared to neutral (18), adequate P (17), and TE (18), respectively. The increased CBG encroachment was explained by the reduced ABG turf quality (<6.5) and clipping yield. Additionally, Ca and P in ABG leaf tissue were lower in acidic and low P treatments, respectively. Findings suggest that adjusting rootzone pH (acidic), paclobutrazol application, or withholding phosphorous increases CBG encroachment into ABG.

40 - Carrot Seed Priming to Speed up Emergence and Canopy Closure.

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Slow emergence and narrow leaf architecture result in a long Critical Period of Weed Control (CPWC) in carrots. This timeframe is especially long when carrots are planted in soils above their ideal germination temperature of 30°C. This is an issue for growers in New England who usually plant fall-harvest carrots in mid-July, which is the hottest part of the year. Strategies such as planting varieties that germinate better in hot soils, and increasing the seeding density can result in greater leaf canopy earlier in the season. Carrot seed priming may be another strategy that can improve germination rates and speed in hot conditions, but has only been measured in laboratory experiments.

41 - Machine Vision-Guided Targeted Herbicide Applications for Kyllinga spp. Control in Turfgrass Systems

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Green kyllinga (*Kyllinga brevifolia*) and false-green kyllinga (*Kyllinga gracillima*) are perennial weeds, increasingly problematic in managed turfgrass systems. Current management strategies rely on sequential applications of acetolactate synthase (ALS)-inhibiting herbicides; however, *Kyllinga* spp. resistance to ALS inhibitors has been reported. Machine-vision targeted spraying (MVTS) may enable the use of herbicides and tank mixtures otherwise limited by cost or turfgrass injury. Three field experiments were conducted in 2025 and 2026 at Raleigh, NC and Blacksburg, VA to compare spray volume reduction, application efficiency, *Kyllinga* spp. control, and turfgrass cover between broadcast and targeted applications of herbicide programs applied by MVTS. Experiments were arranged as two-factor factorial

(application method × herbicide) in randomized complete block design, replicated four times. Treatments included a nontreated control, glyphosate, pelargonic acid, pyrimisulfan, tank mixture of sulfentrazone + pyridate, and tank mixture of bentazon + halosulfuron + sulfentrazone. Herbicides were applied broadcast or targeted using ALBA (Ecorobotix Inc.) at 400 L ha^{-1} and 3.5 km hr^{-1}. Depending on weed density, targeted spraying reduced spray volume by 56 to 74% and increased application efficiency fivefold compared to broadcast applications, while maintaining precision, recall, and F-score values ≥0.82. At 8 weeks after treatment (WAT), all herbicides except pelargonic acid provided >77% *Kyllinga* spp. control following a single application. Broadcast glyphosate reduced turfgrass cover to 34%, while other treatments did not affect turfgrass cover regardless of application method. Targeted spraying maintained comparable weed control while reducing spray volume and improving application efficiency. These findings highlight the potential of MVTS to facilitate single-application *Kyllinga* spp. management using glyphosate or novel herbicide mixtures with different sites of action while minimizing turfgrass injury. Future research will investigate weed density thresholds to optimize herbicide savings when managing rhizomatous perennial weeds, including purple nutsedge and *Kyllinga* spp. with targeted applications.

42 - Atrazine-Alternative Herbicide Programs for Postemergence Weed Control in Sweet Corn

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HPPD-inhibiting herbicides are commonly tank-mixed with atrazine (WSSA Group 5) to improve weed control effectiveness, but atrazine performance can be inconsistent and soil carryover creates vegetable crop rotation restrictions. Therefore, there is a need to develop additional tank mixture partners to improve HPPD-inhibiting herbicides performance. This research examined whether pyridate and bentazon, photosystem II inhibitors (WSSA Group 6) that bind at a different site on the D1 protein, can replace atrazine as tank-mix partners with mesotrione or topramezone in sweet corn (*Zea mays* L. var. saccharata). Field experiments were conducted in 2026 at Fremont and Wooster, Ohio, and analyzed by site using mixed effect models. HPPD + bentazon mixtures provided the greatest common purslane (*Portulaca oleracea* L.) control (91 to 98%) and reduced biomass by more than 96% at both sites; HPPD + pyridate mixtures provided 65 to 86% control with topramezone and 8 to 71% control with mesotrione. At Wooster, topramezone mixtures provided 75 to 96% yellow foxtail [*Setaria pumila* (Poir.) Roem. & Schult.] control and reduced biomass by 81 to 99%, whereas mesotrione mixtures provided 27 to 53% control and mainly did not reduce biomass. At Fremont, both HPPD herbicides provided similar large crabgrass [*Digitaria sanguinalis* (L.) Scop.] control (72 to 93%). Atrazine + pyridate + topramezone was consistently among the most effective treatments (84 to 97% control). Pyridate at 700 g ai ha^{-1} caused transient leaf burn. Overall weed competition reduced crop yield by 55 to 75%, but yield did not differ among tank-mix partners within each HPPD herbicide. Pyridate and bentazon can therefore replace atrazine without lasting injury or yield loss when selected by weed spectrum: bentazon for broadleaf weeds and pyridate for grasses.

43 - Turf Quality, Weed Control, and Cost of Vision-Guided Herbicide Programs in Bermudagrass

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Broadcast application of selective synthetic herbicides is the standard approach for broadleaf weed control in bermudagrass [*Cynodon dactylon* (L.) Pers.], but it treats turf whether or not weeds are present. Nonselective herbicides control more weeds but can injure turfgrass, and organic herbicides are more expensive than synthetic herbicides. Machine-vision sprayers could reduce the treated area, cost, and visible injury, yet peer-reviewed research on commercial units in turfgrass systems is scarce. This study evaluated a machine-vision sprayer prototype applying four herbicides (a premix of 2,4-D, mecoprop-P, dicamba, and carfentrazone-ethyl; glufosinate; iron HEDTA; and acetic acid) to bermudagrass infested with white clover (*Trifolium repens* L.), dandelion (*Taraxacum officinale* F.H. Wigg.), and common chickweed [*Stellaria media* (L.) Vill.]. Three field experiments were conducted in 2025 in Blacksburg, VA, and Raleigh, NC, each as a randomized complete block design with four replications. Area sprayed was quantified by colorimetric selection of spray stains from aerial images. Turfgrass injury, dark green color index (DGCI), and weed density were assessed weekly through 84 days after treatment (DAT). Targeting accuracy was 95 to 96% for broadleaf weeds, and herbicide use was reduced by 80 to 87%. This lowered chemical cost by $93 to $1,103 ha^{-1}, with the largest savings for acetic acid and iron HEDTA. Glufosinate caused the most turfgrass injury (54% at 7 DAT; 35% at 28 DAT) and reduced DGCI. Acetic acid caused transient bermudagrass injury that did not exceed 37%, and the synthetic premix and iron HEDTA injured bermudagrass no more than 19%. At 84 DAT, targeted applications of the synthetic premix, iron HEDTA, glufosinate, and acetic acid reduced broadleaf weed density by 85, 75, 64, and 56%, respectively. Targeted application substantially lowered the cost of the organic herbicides, whereas acetic acid and glufosinate lost efficacy more rapidly than the synthetic premix. Further research should test repeat treatments of targeted organic herbicides to improve weed control.

44 - Seeing Weeds, Spraying with Precision: Targeted Weed Control in Tree Fruits

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Michigan ranks third and fourth nationally in apple and highbush blueberry production, respectively. Weed management is essential but costly in tree fruit systems. Conventional growers balance effective weed control with herbicide costs and crop safety, whereas organic growers have limited herbicide options. Targeted spraying may improve application efficiency by treating weeds rather than the entire orchard floor. Targeted spraying technologies like those from WEED-IT detect green vegetation and apply herbicide only where weeds are present, potentially reducing herbicide volume and off-target injury. However, savings may depend on weed management history, weed species composition, weed density, and the effectiveness of preemergence (PRE) herbicides. In 2026, two field experiments in Michigan

evaluated the effects of PRE herbicide programs that maximize spray-volume savings through targeted-spraying technology. The first experiment, conducted in apple orchards in Clarksville and Holt and blueberry sites in Grand Junction, compared four weed management programs combining PRE or no PRE applications with broadcast or targeted postemergence (POST) spraying. All programs received glufosinate (1,150 g ai ha^{-1}) for burndown; PRE programs additionally receiving rimsufuron (70 g ai ha^{-1}) plus *S*-metolachlor (1390 g ai ha^{-1}). POST applications consisted of clethodim (136 g ai ha^{-1}) plus carfentrazone-ethyl (35 g ai ha^{-1}), applied using broadcast spraying or targeted spraying with WEED-IT. The second experiment, conducted in an apple orchard in Clarksville, eight PRE programs included indaziflam (95 ai g ha^{-1}), pendimethalin (4260 ai g ha^{-1}), rimsulfuron (70 ai g ha^{-1}), and their combinations, followed by clethodim plus carfentrazone-ethyl applied with WEED-IT two or four months after PRE treatment. Spray-volume savings were measured during each POST application. Weed density was assessed two weeks after POST application in the first experiment and percent control eight weeks after the second POST application in the second experiment. In the first experiment, PRE herbicides did not significantly affect grass (*Poaceae*) control across fruit systems; however, WEED-IT targeted spraying reduced grass density by 81% compared to broadcast spraying. PRE followed by broadcast application reduced dandelion (*Taraxacum officinale* L.) density by >60% compared to no PRE application and was comparable to targeted spraying technology. The inclusion of PRE herbicides reduced POST spray volume applied by an additional 11% to 37% with the WEED-IT targeted spraying technology compared with programs without a PRE herbicide, depending on location and crop. In the second experiment, the three-way PRE mixture followed by WEED-IT targeted spraying provided 93% dandelion control four months after PRE. Grass control varied among POST timings, with delaying POST application from two to four months improving control by 19%. Canada thistle (*Cirsium arvense*), carolina horsenettle (*Solanum carolinense*), common lambsquarters (*Chenopodium album*), and red sorrel (*Rumex acetosella*) were not affected by the evaluated treatment programs. Depending on PRE program and timing, 23% to 47% of the prepared spray mixture was saved. Overall, PRE herbicides increased spray-volume savings with WEED-IT, although weed responses varied among species and programs. Future research should develop weed species-specific herbicide programs and determine whether targeted spraying can reduce crop injury from normally injurious herbicides and enable their in-season use.

45 - Herbicide Control of Goosegrass (*Eleusine indica* L.) Following Paclobutrazol Application

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[1]Iowa State University

Goosegrass (*Eleusine indica* L.) is a grass weed that is a problem creeping bentgrass (*Agrostis stolonifera* L.) golf system. This prompted the evaluation of paclobutrazol on herbicide efficacy of goosegrass in a sand-capped creeping bentgrass fairway. An experiment utilizing a randomized complete block design was arranged in a two by three factorial, across four blocks, during the summer of 2026. Nine goosegrass plants that were transplanted into each plot. The first main effect contained two paclobutrazol treatments: 0 g ai ha^{-1} and 560 g ai ha^{-1}. While the second main effect contained three herbicide treatments: a nontreated (0 g ai ha^{-1}), a topramezone treatment (6 g ai ha^{-1}), and a carfentrazone+2,4-D+MCPP-P+dicamba treatment (28 g ai ha^{-1}, 889g ae ha^{-1}, 294 g ae ha^{-1}, and 84 g ae ha^{-1}, respectively) which were

all applied seven days after the paclobutrazol application. Visual herbicide efficacy was recorded every seven days following herbicide application until 35 days after application where goosegrass aboveground shoot biomass was harvested, with fresh and dry biomass values recorded afterwards. Data were analyzed in JMP Student Edition 18 using an ANOVA, followed by mean separation with Tukey's HSD at α=0.05. There was an interaction in the herbicide visual efficacy data between paclobutrazol and herbicide factors (P = 0.0094), and no other interactions were present. When carfentrazone+2,4-D+MCPP-P+dicamba was applied to plots that were previously treated with paclobutrazol (5% visual herbicide efficacy) versus those that were not treated with paclobutrazol (19.5% visual herbicide efficacy) after 35 days. There were also differences in the fresh and dry weight data by paclobutrazol (P=0.0178 and 0.0115 respectively) and herbicide treatment (P<0.0001 for both data columns). Goosegrass fresh shoot biomass averaged 0.978 g plot^{-1} when paclobutrazol was applied and 0.559 g plot^{-1} when paclobutrazol was not applied. Goosegrass dry shoot biomass reflected what was observed in the fresh shoot biomass, with 0.162 g plot^{-1} when paclobutrazol was applied and 0.094 g plot^{-1} when paclobutrazol was not applied. Goosegrass fresh shoot biomass was similar when carfentrazone+2,4-D+MCPP-P+dicamba or no herbicide was applied (1.037 g plot^{-1} and 1.222 g plot^{-1}, respectively) but not similar to topramezone applications (0.046 g plot^{-1}). Goosegrass dry shoot biomass was similar when carfentrazone+2,4-D+MCPP-P+dicamba or no herbicide was applied (0.168 g plot^{-1} and 0.205 g plot^{-1} respectively) but not similar to topramezone applications (0.012 g plot^{-1}). Therefore, topramezone is the best recommendation for control of goosegrass following paclobutrazol.

46 - Effects of Preemergence and Postemergence Herbicides on Several Weeds in High Organic Matter Soils

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Weed control in vegetable production on high organic matter soils (>20% organic matter) is challenging due to lack of effective herbicides, leaving growers heavily reliant on glyphosate and hand weeding which are challenged by development of glyphosate-resistant weed populations and labor scarcity. Field experiments were conducted in Willard, Ohio, in 2025 and 2026 to evaluate five preemergence (PRE) and seven postemergence (POST) herbicides for controlling common purslane (*Portulaca oleracea* L.) and pigweed spp. (*Amaranthus* spp.), two problematic weeds in Ohio vegetable crops. Herbicide treatments were evaluated during an early-season period (May 2026) and late-season periods (July 2025 and July 2026) in a randomized complete block design with four replications. During the early-season evaluation, oxyfluorfen PRE 561 g ai ha^{-1} provided the greatest (more than 93%) common purslane and pigweed spp. control 2 weeks after treatment (WAT). These results were reflected in aboveground biomass reductions 4 WAT, where oxyfluorfen PRE and flumioxazin 106 g ai ha^{-1} + pyroxasulfone 134 g ai ha^{-1} PRE reduced total weed biomass by 81% compared with nontreated control. During the late-season evaluations, flumioxazin + pyroxasulfone PRE provided the greatest and most consistent residual control, resulting in more than 90% common purslane control and more than78% pigweed spp. control 2 WAT in both years. Among POST treatments, saflufenacil 50 g ai ha^{-1} and linuron 840 g ai ha^{-1} consistently provided the highest common purslane and pigweed spp. visual control and biomass reduction (more than 90%) compared with nontreated control. These results provide support for the labelling of additional herbicide

options that can be used for common purslane and redroot pigweed control on organic soils. However, further studies are needed to evaluate the crop responses to these herbicides on organic soils.

47 - Preemergence Herbicides Reduce Marketable Stems of Tuberose (*Polianthes tuberosa*) Cut Flowers

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Tuberose (*Polianthes tuberosa*) is a popular field-grown cut flower. Tuberose is propagated by bulbs and in the Southeastern U.S. plantings remain in the ground for 3 to 4 years. At present, there are no herbicides registered for use on tuberose. This experiment was established to screen herbicides for safety to tuberose. On May 9, 2026, tuberose bulbs donated by a local grower were sorted by size and potted into 4-L pots using a soilless substrate (9:1 v/v, hammer-milled pine bark + sand, amended with lime). Pots were top-dressed with 20 g each of slow release nursery fertilizer, hand watered and thereafter irrigated daily with about 1.9 cm water. Herbicides were applied on May 21st and again on July 8th. Treatments include a single labeled dose of s-metolachlor, dimethenamid-p, prodiamine, isoxaben + prodiamine (spray and granular formulations), dimethamid-p + pendimethalin GR, and halosulfuron. Treatments were arranged in a randomized complete block design, with four replicates. Each experimental unit contained 3 potted tuberose plants. Percent injury to the plants was visually evaluated approximately every 2 weeks until 6 weeks after the 2nd applications. Injury ratings focused only on foliar size and quality parameters, not flowering. The number and length of flower stems was recorded throughout the season. Flower harvest continued through mid-October. The number of flowers harvested each week were recorded and the cumulative number of stems were calculated. Data for flower stems numbers were highly variable; therefore, for these data only an α of 0.1 was used to compare treatment means. Halosulufron injured tuberose plants. Plants were smaller than in the nontreated and all other herbicide treatments. No other treatment injured plants following the first application. Following the 2nd application, Gemini G, the granular formulation of isoxaben + prodiamine, caused foliar necrosis where granules were caught in the whorl of new leaves. No injury was observed from the spray application of isoxaben + prodiamine, prodiamine, s-metolachlor, dimethenamid-p, or the granular formulation of dimethenamid-p + pendimethalin. Only Gemini G reduced the height of flowering stems compared to the nontreated. But, all herbicides reduced the total number of flower stems. Halosulfuron was the most injurious treatment, delaying and reducing flowering. Results from this experiment suggest that preemergence herbicides may reduce cut flower production in tuberose plantings. However, tuberose cut flowers not typically grown in containers. Field planted tuberose bulbs and established plantings may respond differently to herbicide treatments.

48 - Automating Mechanical Weed Management on Small Vegetable Farms

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Management of weeds and seeding on small-scale vegetable farms is often completed using manual labor, which is costly and physically intensive. Use of robotic weeding and seeding has the potential to reduce labor needs on a small-scale farm, though efficacy in field trials needs to be evaluated. The farm-ng Amiga robot utilizes a wired controller, allowing the user to control the robot to complete the desired task. Seeding and weeding was performed by robot and by hand to predict feasibility in real-field scenarios. Radish (*Raphanus sativus* L.) was planted in 3.8 m x 0.9 m beds at Waterman Farm, Columbus, OH. Each crop had four replicates of each combination of robot-planted or manually-planted with manual-weeded or robot-cultivated beds. Seeding was completed in late June utilizing three 20 cm spaced crop rows and 0.64 cm in-row spacing. Crop stand and grass and broadleaf weed counts were collected prior to cultivation using 0.5 m^2 quadrats in early July. Afterwards, cultivation was performed manually using a stirrup hoe or mechanically using the robot. Post-cultivation crop stand and weed counts were collected approximately one week after cultivation. An additional crop stand and weed count was performed in mid July. In late July, final crop stand and weed counts were taken and radishes were harvested. Fresh weight was segmented into total weight, marketable weight, and damaged weight. The robot greatly reduced the average time of seeding compared to manual seeding. Initial crop stand for manually-seeded rows were significantly higher than the robot-seeded rows, however, this did not persist after cultivation. Robot cultivation was comparable to manual cultivation in broadleaf weeds, though plots receiving robot seeding and cultivation saw an increase in grass weeds after first cultivation. Seeding method affected the number of radishes that were marketable, with robot-seeded methods yielding significantly less marketable radishes. Future research utilizing more crops, increasing scale, and upgrading the robot for reliability, precision, and autonomy will help better determine benefits, labor savings, and feasibility for farmers.

49 - Impact of Metamitron on Weed Control and Crop Safety in Garden Beet

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A field trial was conducted to investigate the impact of metamitron on weed control and crop safety in garden beet.

50 - Clomazone Application Timing for Poa annua Control in Overseeded and Dormant Bermudagrass

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Bermudagrass turf is often overseeded with perennial ryegrass to improve winter color, but this limits herbicidal options for annual bluegrass control. Herbicides that control annual bluegrass may injure bermudagrass or perennial ryegrass, which often differ in their response to herbicide modes of actions. Herbicide applications prior to overseeding may control annual bluegrass but injure bermudagrass and interfere with perennial ryegrass establishment. Field studies were conducted across multiple sites during 2024 and 2025 to evaluate annual bluegrass control, bermudagrass injury, and perennial ryegrass establishment following clomazone and foramsulfuron applications. Treatments were clomazone at 841 g ai ha^{-1} and foramsulfuron at 29 g ai ha^{-1} applied 7 d before overseeding, and a nontreated control. Both herbicides controlled annual bluegrass over 90% 10 WAT, and over 85% 20 WAT. Clomazone bleached the bermudagrass up to 90% 2 WAT; however, injury was transient and declined to less than 10% by 6 WAT. The effect of clomazone on perennial ryegrass establishment was variable between trials, but generally comparable to foramsulfuron. One out of six trials had a delay in perennial ryegrass establishment, suggesting that perennial ryegrass response to clomazone varies across environments; however, by 6 WAT establishment was similar across both treatments. Overseeding perennial ryegrass could potentially mask the visual bleaching effect observed in bermudagrass depending on establishment. However, delayed or reduced perennial ryegrass emergence may prolong injury visibility. These findings indicate that clomazone can control annual bluegrass comparably to foramsulfuron but causes transient bleaching of bermudagrass for up to 6 WAT and variable perennial ryegrass establishment may limit its utility in overseeded bermudagrass systems.

51 - Unmanned Aerial Systems-based Spray Applications in Watermelon (Citrullus lanatus)

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Unmanned Aerial Systems (UAS) offer a promising alternative to conventional ground-based herbicide applications. However, it remains unclear whether the lower spray volumes used in UAS applications can provide weed control equivalent to conventional applications while maintaining watermelon yields. A field study was conducted at ESAREC, Painter, VA in 2026 to evaluate weed control, droplet size, and watermelon yield with herbicides applied with a UAS at 75, 37, and 19 L ha^{-1}, compared with conventional ground application at 140 L ha^{-1}. The experiment used tank mix of Sandea, Curbit, and Reflex as pre-emergence (PRE) herbicide and Select Max as the postemergence (POST) herbicide. Droplet size (Volume Median Diameter) obtained with backpack spray application was 431 µm at 140 L

ha^{-1} and VMD decreased for UAS 319 to 179 µm as spray volume decreased, from 75 to 19 L ha^{-1}. PRE application provided 83 to 97% control of yellow nutsedge, curly dock, and large crabgrass, and weed control did not differ among spray volumes for curly dock and large crabgrass. POST application provided 77 to 90% control of Palmer amaranth, with no differences among spray volumes. However, Texas millet control was lower with the UAS at 75 and 19 L ha^{-1} (67 to 68%) than with the ground application (91%). Weed biomass after the PRE and POST applications was lowest at 19 and 75 L ha^{-1}, respectively. Watermelon yield with the UAS at 75 L ha^{-1} (2,652 kg ha^{-1}) was similar to the ground application at 140 L ha^{-1} (3,802 kg ha^{-1}), whereas yields were lower at 37 and 19 L ha^{-1}, and the 19 L ha^{-1} treatment (392 kg ha^{-1}) did not differ from the nontreated control (221 kg ha^{-1}). These first-year results indicate that UAS herbicide applications at higher spray volumes may provide weed control and watermelon yield comparable to conventional ground applications. The study will be repeated to confirm these findings and to further evaluate the effects of reduced spray volumes on weed control and crop yield.

52 - Expanding Herbicide Options for Weed Management in Edamame (*Glycine max* (L.) Merr.).

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Edamame (*Glycine max* (L.) Merr.) is a specialty vegetable soybean gaining popularity in the United States due to its nutritional value and increasing consumer demand. However, domestic production remains constrained by limited weed management options, particularly the availability of registered herbicides compared with grain soybean. Identifying additional herbicides that provide effective weed control without compromising crop safety is essential for developing reliable weed management programs in edamame. Field experiments were conducted in 2024 and 2025 at the Virginia Tech Eastern Shore Agricultural Research and Extension Center in Painter, Virginia, to evaluate the efficacy and crop tolerance of selected preemergence (PRE) herbicides. The experiments were established in a randomized complete block design with three replications using edamame cultivar ‘VT Sweet’. Twenty PRE herbicides, including single-active products and premixes commonly used in grain soybean, were evaluated. Herbicides not currently registered for edamame were applied at rates recommended for grain soybean. PRE herbicide treatments significantly influenced early-season weed control, although treatment responses varied between years. Greater differences in weed control among herbicides were observed in 2024, whereas efficacy was generally more consistent in 2025, likely due to greater rainfall and prolonged soil moisture favoring herbicide activation. Among single-active herbicides, pyroxasulfone provided 94-98% weed control across both years, followed by flumioxazin (93%), metribuzin (89-93%), and S-metolachlor (83-93%). Several premixed herbicides also demonstrated excellent weed control, particularly S-metolachlor + metribuzin + cloransulam-methyl (Tendovo®) (97-99%) and S-metolachlor + fomesafen (Prefix®) (95-97%), which consistently performed well across both growing seasons. Crop tolerance was generally favorable, with most herbicide treatments causing ≤ 5% visible injury. Minor injury was observed with saflufenacil, S-metolachlor, metribuzin, linuron, and sulfentrazone + carfentrazone-ethyl (Spartan Charge®), but overall injury levels remained low. These findings

demonstrate that several PRE herbicides currently used in grain soybean have the potential for effective early-season weed management in edamame with minimal crop injury. Further evaluation of promising herbicides could support expanded registration options and the development of more flexible and effective weed management programs for domestic edamame production.

53 - Electricity Against Yellow nutsedge (Cyperus esculentus): Targeted Weed Control in Onion Row Middles

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Michigan onions are valued at $18 million, with most production on muck soils. Onions compete poorly with weeds because their limited canopy development provides insufficient weed suppression. Yellow nutsedge (*Cyperus esculentus* L.) is a particular concern because it is difficult to control with herbicides, cultivation, or hand-weeding and can substantially reduce onion yield. Growers report five to eight herbicide applications per season and hand-weeding costs of $250-$1,240 ha^{-1}. Limited herbicides, resistance concerns, and crop sensitivity further complicate management. Cultivation controls between-row weeds but disturbs muck soils, potentially accelerating erosion, stimulating new weed emergence, and spreading yellow nutsedge by disrupting underground structures. Electrical weed control (EWC) is a non-chemical approach that could reduce soil disturbance, herbicide use, and hand-weeding needs. However, current electrode-based systems lack crop selectivity and can severely injure onions. We therefore evaluated a zonal strategy combining directed herbicides within onion rows with EWC between rows, aiming to reduce seed return and weed spread toward the crop. We hypothesized that treating yellow nutsedge between rows could suppress in-row shoots through connected rhizomes. In 2026, a field study at Keilen Farms, Lansing, Michigan, evaluated EWC energy dose and application frequency in onions. The study was arranged in a randomized complete block split-plot design with four replications. The main plot factor was EWC energy dose of 6.7 and 13.4 kJ m^{-2}. The subplot factor was application program, with four levels: one pass at the onion 2-leaf stage; two passes at the 2- and 4-leaf stages; three passes at the 2-, 4-, and 6-leaf stages; and four passes at the 2-, 4-, 6-, and 8-leaf stages. Before onion emergence, all plots received pendimethalin (2,248 g ai ha^{-1}) plus bromoxynil (279 g ai ha^{-1}). Electrical treatments were applied using a push-behind eWeeding Roller Zasso™ unit. Standard herbicides were directed to a 20-cm band encompassing four onion rows, while EWC treated 60 cm of the 70-cm row middle, reducing the in-season herbicide-treated area by 78% relative to broadcast spraying. Yellow nutsedge density was assessed at 14, 30, 50, and 65 days after the initial EWC treatment (DAIT), and biomass was measured at 65 DAIT. Onion yield was recorded at harvest. At 14, 30, and 50 DAIT, increasing energy dose from 6.7 to 13.4 kJ m^{-2} reduced yellow nutsedge density by 34% (160 vs 105 plants m^{-2}), 58% (147 vs 62 plants m^{-2}) and 46 % (242 vs 131 plants m^{-2}). However, EWC energy dose had no effect on yellow nutsedge density or aboveground biomass at 65 DAIT, and onion yield was unaffected. Contrary to our hypothesis, between-row EWC did not suppress yellow nutsedge growing within the onion rows. In conclusion, higher EWC energy improved short-term yellow nutsedge suppression, and the zonal strategy reduced the area requiring directed herbicides without reducing onion yield. Future research should evaluate more precise EWC applications during early onion development, particularly between emergence and the first true leaf, when herbicide options are limited, and determine

whether repeated between-row treatments reduce subsequent weed emergence and long-term weed pressure.

Student Poster Contest – Integrated Weed Management and Cover Crops

54 - Impact of Cereal Rye Biomass and Postapplication Rainfall on Waterhemp Control with Soil-Residual Herbicides

Sophia Bez Ribeiro[1], Sabeel Abuhakmeh[1], Ahmadreza Mobli[1], Rodrigo Werle[1]

[1]University of Wisconsin

Waterhemp (*Amararantus tuberculatus* (Moq) J.D. Sauer) is a major weed in U.S. corn and soybean production systems, and the alarming increase in resistance to multiple herbicide sites of action has emphasized the need for integrated weed management strategies. Cereal rye (*Secale cereale* L.) can suppress weed emergence and growth but may intercept preemergence herbicides, potentially affecting their efficacy. Delayed rainfall after application may reduce herbicide efficacy, particularly when herbicides are intercepted and retained by crop residue, potentially limiting the amount of active ingredient reaching the soil. This study evaluated the effect of cereal rye residue and following rainfall regimes on the efficacy of preemergence herbicides for waterhemp control. A controlled environment greenhouse experiment was conducted using a completely randomized design with six replications in two experimental runs and a 2 × 22 × 3 factorial arrangement. Treatments consisted of no and yes cereal rye residue (4 Mg ha^{-1}), 22 herbicide treatments including a nontreated control, and simulated rainfall delays of 0, 7, and 14 days after PRE application. At 28 days after application (DAA), the mulch was removed, the upper 2 cm of soil was gently loosened, and waterhemp seeds were incorporated (~200 seeds/pot). Waterhemp emergence and aboveground biomass were evaluated 56 DAA (28 days after waterhemp seeding). Data were subjected to analysis of variance. When significant treatment effects were detected, means were compared using Tukey's HSD test ($\alpha = 0.05$). Nine herbicide treatments provided >90% waterhemp biomass reduction regardless of cereal rye residue presence: acetochlor (non-encapulsated [Harness] 1261 and 1960 g ai ha^{-1}; and encapsulated [Warrant], 1261 g ai ha^{-1}), dimethenamid-P (Outlook, 736 g ai ha^{-1}), fomesafen (Flexstar, 263 g ai ha^{-1}), mesotrione (Callisto, 175 g ai ha^{-1}), pyroxasulfone (Zidua SC, 110 g ai ha^{-1}), *S*-metolachlor (Dual II Magnum, 1792 g ai ha^{-1}), and sulfentrazone (Spartan 4F, 210 g ai ha^{-1}). Four herbicide treatments provided >90% waterhemp biomass reduction in the absence of cereal rye residue but the efficacy reduced when mulch was present: diflufenican (Convintro, 150 g ai ha^{-1}), flumioxazin (Valor EZ, 70 g ai ha^{-1}), metribuzin (Tricor DF, 420 g ai ha^{-1}), and pendimethalin (Prowl H_2O, 1060 g ai ha^{-1}). Eight treatments: atrazine (AAtrex, 1120 g ai ha^{-1}), chlorimuron-ethyl (Classic, 21 g ai ha^{-1}), clomazone (Command 3ME, 1120 g ai ha^{-1}), clopyralid (Stinger, 131 g ai ha^{-1}), cloransulam-methyl (FirstRate, 35 g ai ha^{-1}), imazethapyr (Pursuit, 70 g ai ha^{-1}), isoxaflutole (Balanace Flexx, 79 g ai ha^{-1}), and saflufenacil (Sharpen, 24 g ai ha^{-1}) provided <90% efficacy regardless of residue presence. Random Forest analysis identified herbicide selection as the primary driver of waterhemp biomass reduction (88% relative permutation importance), followed by rainfall timing (10.9%) and cereal rye

residue (1.1%). Overall, effective residual herbicide programs targeting waterhemp can be compatible with integrated weed management systems.

55 - The Effectiveness of Pre-Emergence Herbicides with a Cover Crop for Weed Control in Corn

Morgan Ourada[1], Joaquin Enrria[1], Joey Rains[1], Anita Dille[1]

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Weed control is one of the most challenging aspects of the crop growing season. Repeated use of herbicides in crop fields has led to weeds that are not controlled or have become resistant. Alternative methods to reduce or eliminate herbicide use should be explored. Cover crops have been a part of several studies showing success in accomplishing weed suppression. Including soil-applied residual herbicides together with cover crops have also been a question to improve weed control. This on-farm experiment focused on the effectiveness of four soil-applied residual group 15 herbicides: dimethenamid-P, s-metolachlor, pyroxasulfone, acetochlor and a no residual treatment, when combined with a cover crop before planting corn (***Zea mays)*** to delay or eliminate foliar-applied post-emergence passes. Three on-farm studies were conducted in 2026 across Nebraska and Kansas. Cover crops were terminated with glyphosate, Roundup Power Max, within one week of corn being planted, residual herbicide treatments were also applied in the same tank mix. Emerging weeds were then documented on a regular basis until crop canopy closure, or the established threshold was reached. Overall, acetochlor, pyroxasulfone, and s-metolachlor were successful in delaying the first post-emergence spray pass, however dimethenamid-P was not successful with the highest weed counts and variability of all the treatments. Across the three sites the threshold was reached around 38-43 days after treatment application, the cover crop and soil-applied residual herbicides provided several weeks of weed control before a post-emergence spray pass would be needed.

56 - Palmer Amaranth Control with Hairy Vetch and Herbicides in Quizalofop-Resistant Sorghum

Sai Suvidh Maddela[1], Stevan Knezevic[1], Milos Zaric[1], Amit J. Jhala[1]

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Information on integrated weed management in grain sorghum [*Sorghum bicolor* (L.) Moench] remains limited, even in Nebraska, one of the leading sorghum-producing states. Multiple herbicide-resistant Palmer amaranth (*Amaranthus palmeri* S. Watson) is difficult to control because sorghum’s sensitivity to many herbicides limits available chemistries. Quizalofop-resistant grain sorghum allows postemergence (POST) grass control, but quizalofop does not control broadleaf weeds such as Palmer amaranth. Hairy vetch (*Vicia villosa* Roth), a winter annual legume cover crop, can suppress weeds and supply nitrogen, but its optimal termination timing in sorghum is unknown. This study evaluated termination timing effects on hairy vetch biomass, Palmer amaranth density and biomass, and soil nitrate-N in quizalofop-resistant

grain sorghum. A field experiment was conducted in 2025-2026 at the South-Central Agricultural Laboratory near Clay Center, Nebraska, in a split-plot design with three replications. Main plots were five termination timings: no cover crop; hairy vetch terminated 1 week (wk) before sorghum planting; at planting; at sorghum V2; and hairy vetch not terminated. Subplots were four herbicide programs: a no-herbicide check; acetochlor plus atrazine preemergence (PRE); PRE followed by quizalofop and halosulfuron plus dicamba plus atrazine POST; and the same program with encapsulated acetochlor added POST. Palmer amaranth density and biomass were recorded 14 and 28 days after sorghum planting (DAP) and soil nitrate-N was measured at 0 to 20 cm. Data averaged across herbicide programs were analyzed with linear mixed models in R, and means were separated with Tukey’s test ($\alpha = 0.05$). Hairy vetch fresh biomass did not differ between the V2 (2,551 kg ha^{-1}) and not terminated (2,926 kg ha^{-1}) treatments. Termination timing affected Palmer amaranth biomass ($P < 0.001$) similarly at 14 and 28 DAP ($P = 0.62$). At 28 DAP, Palmer amaranth biomass was 21.2 g m^{-2} without a cover crop compared with 1.9 and 0.7 g m^{-2} when hairy vetch was terminated at V2 or not terminated, a 91% and 97% reduction, respectively. Terminating hairy vetch 1 wk before planting reduced Palmer amaranth biomass 70% (6.3 g m^{-2}), whereas termination at planting (8.8 g m^{-2}) did not differ from no cover crop. At 14 DAP, Palmer amaranth biomass was 89% lower in the V2 and not-terminated treatments than without a cover crop, though the difference was not significant. Palmer amaranth density followed a similar trend ($P = 0.028$): 1.6 plants m^{-2} in the V2 and not-terminated treatments vs. 9.7 to 12.4 plants m^{-2} in others at 28 DAP, with no significant pairwise differences. Soil nitrate-N was 11.2 and 12.0 kg ha^{-1} when hairy vetch was terminated at V2 or not terminated, three to eight times greater than in the other treatments (1.5 to 3.5 kg ha^{-1}). Delaying hairy vetch termination until sorghum V2, or leaving it unterminated, suppressed early-season Palmer amaranth and increased soil nitrate-N, but living hairy vetch competed with sorghum and reduced crop stand. Termination timing must therefore balance Palmer amaranth suppression against crop competition; interactions with herbicide programs and effects on sorghum grain yield warrant further research.

57 - Influence of Cereal Rye Biomass on Postemergence Spray Coverage Interception and Control of Amaranthus tuberculatus.

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Waterhemp (*Amaranthus tuberculatus*) is one of the most troublesome agronomic weed species in the U.S. Midwest, mainly due its extended emergence period, rapid growth, prolific seed production, and wide range of herbicide resistance. In order to enhance waterhemp control, many farmers are adopting cover crops as an integrated strategy. While cover crop mulch interception of preemergence herbicides has been broadly documented, its effects on spray coverage during postemergence applications have been less extensively studied. The objective of this study was to assess how different cereal rye (*Secale cereale*) mulch levels affect postemergence herbicide spray coverage and subsequent waterhemp control. This field study was conducted in 2026 at Arlington Agricultural Research Station in a completely randomized design with twelve replications of each treatment (study will be replicated in 2027). Three cereal rye mulch levels were tested: no cereal rye mulch, intermediate mulch (cereal rye terminated at 48

cm tall), and high mulch (cereal rye terminated at 84 cm tall). Nine waterhemp seedlings, approximately 2.5 cm tall, were transplanted in a single row in between the middle soybean rows, extending from the front to the back of each plot. Biomass of the first three plants within each plot was collected at the time of post application. The six final plants of each plot received a postemergence herbicide application when plants averaged 11 cm tall. The application consisted of 2,4-D (1,065 g ai ha^{-1}) + glufosinate (370 g ai ha^{-1}) + ammonium sulfate (2,242 g ai ha^{-1}), using AIXR 110015 nozzles at a spray volume of 140 L ha^{-1}. At the time of application, plant height, number of leaves, main-stem nodes, and secondary nodes were recorded for the sprayed plants. Three water sensitive spray cards (5.2 x 7.6 cm) were placed at ground level in each plot to assess spray coverage. Twenty-one days after application (DAT), visual assessment of waterhemp control, and plant mortality data were recorded for the six treated waterhemp plants per plot, and their biomass was collected. Spray coverage was 42% greater without cereal rye, and no differences were observed between low and high cereal rye levels (spray coverage = 24%). Waterhemp height at postemergence application did not differ among treatments, but plants growing within high cereal rye had 34%, 12% and 42% fewer leaves, main-stem nodes, and secondary nodes, respectively, than plants growing without cereal rye. Visual assessment of waterhemp control 21 DAT was slightly greater at both low (98%) and high (99%) cereal rye levels than without cereal rye (96%). Although high cereal rye mulch reduced postemergence spray coverage, it didn't reduce waterhemp control following the postemergence application. High cereal rye level altered waterhemp plant structure, highlighting the potential of adopting integrated weed management strategies to sustain waterhemp control.

58 - Effects of Seeding Rate and Row Spacing on Weed Pressure and Economic Outcomes in Organic Corn (*Zea mays*) Production Systems.

Michael Ahiador[1], Racquel Gorden[1], Moshen Shahrokhi[1], Lalit Pun Magar[1], Mercy Odemba[1], Osler Ortez[1], Alyssa Essman[1], Eric Richer[1], Eugene Law[1]

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In-row weeds are difficult to control with mechanical cultivation in organic corn. Cultural practices, such as adjusting seeding rate and row spacing, may improve crop competitiveness and help suppress weeds. This study evaluated how these practices affected individual weed groups and total in-row weed density in an on-station organic corn (*Zea mays L.)* trial in Wooster, Ohio.The experiment used a randomized complete block design with four replications and a split-plot arrangement. Row spacings of 76.2 and 152.4 cm were assigned to main plots, and five seeding rates ranging from 69,200 to 108,700 seeds ha^{-1} were assigned to subplots, giving 40 plots. Two 5.33-m-long transects were established per plot, and treatment effects on in-row weed density were assessed by counting all weeds within 10 cm on either side of the crop row at corn V2, V5, and R3 growth stages. At V2 weeds were counted for the entire transect, and at V5 and R3 they were counted for 1 m of crop row. Counts were standardized by sampled area and expressed as weeds m^{-2}. Individual weed groups were analyzed separately within each sampling stage using split-plot analysis of variance.Observed weed patterns differed among sampling stages. Grasses remained present throughout sampling. Common ragweed (*Ambrosia artemisiifolia L.*) occurred in all 40 plots at V2 but only two plots at R3. At V2, an exploratory analysis detected a seeding-rate effect on giant ragweed (*Ambrosia trifida L.)* density (P = 0.0191). Averaged across row spacings, *A. trifida* density was

lower at 108,700 than at 69,200 and 79,100 seeds ha^{-1}.Averaged across the three sampling rounds, total in-row weed density was not significantly affected by row spacing (P = 0.974), seeding rate (P = 0.719), or their interaction (P = 0.825). These preliminary, single-season results show an early species-specific response but no overall reduction in total in-row weed density from increasing seeding rate or changing row spacing. Additional growing-season data are needed before making weed-management recommendations. Economic analysis is pending, and profitability has not yet been evaluated.

59 - Cereal Rye Biomass Influences Emergence Dynamics of Common Wisconsin Summer Annual Weeds

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Effective season-long weed control in modern soybean production systems requires integrated chemical and non-chemical management strategies. Cereal rye (*Secale cereale* L.) cover crop has been shown to delay weed emergence and reduce density. While the suppressive ability of cereal rye on certain troublesome species has been extensively investigated, its impact on other common species warrants investigation. Field studies were conducted to determine the impact of cereal rye biomass on the emergence of waterhemp [*Amaranthus tuberculatus* (Moq.) J.D. Sauer], common lambsquarters (*Chenopodium album* L.), and foxtail spp. (*Setaria* spp.). Field studies were conducted in 2025 and 2026 near Arlington, WI (common lambsquarters and foxtails), and Janesville, WI (waterhemp), using a randomized complete block design with four replications in naturally infested fields. Cereal rye dry biomass ranged between 4,300-5,500 kg ha^{-1}. Cereal rye biomass reduced total emergence of common lambsquarters by more than 80% in both years compared with no cover crop. Foxtail emergence was reduced in 2025 but not in 2026, when dry conditions resulted in low grass emergence across the experimental area. In 2025, total waterhemp emergence was similar between treatments, but cereal rye biomass delayed the onset of waterhemp emergence, particularly during the first 14 days of the study. In 2026, cereal rye reduced total waterhemp emergence by 65%. Overall, cereal rye suppressed the emergence of small-seeded summer annual weeds evaluated, although its effectiveness varied among species and years. Since this study was conducted under bareground conditions without crop competition, the observed suppression may underestimate the potential effectiveness of cereal rye in soybean production systems, where crop competition and canopy shading could provide additional weed suppression.

60 - Cultural and Physical Seed Reduction Strategies for Managing Palmer amaranth Seed Production

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Palmer amaranth (*Amaranthus palmeri* S Watson) is the most problematic weed species across Nebraska. Multiple herbicide-resistant Palmer amaranth has been confirmed in Nebraska. Each female plant of Palmer amaranth has the potential to produce hundreds of thousands of seeds. Strategies aimed at reducing Palmer amaranth seed production may be a critical management tool for farmers. The objective of this study was to evaluate the effect of row spacing and physical clipping on Palmer amaranth seed production in soybeans. The field study was conducted at University of Nebraska-Lincoln’s South-Central Agricultural Lab near Clay Center, NE. The study utilized a split block design with soybean planted at 38 or 76 cm row spacing. Each block contained a nontreated control, conventional herbicide program (glufosinate + acetochlor) and one or two physical clipping of Palmer amaranth plants. A blanket application of sulfentrazone/pyroxasulfone (Authority Elite) was applied on the same day of planting soybean. The first clipping treatment thirty days after planting involved randomly clipping 20 Palmer amaranth plants 30 cm above the ground. In the second treatment, 60 days after planting a late clipping was applied cutting all biomass above 60 cm. Control ratings, Palmer amaranth biomass, and seed production were collected. Preliminary results show that row spacing alone significantly reduced palmer amaranth seed production. Treatments were compared based on percent reduction in seed production relative to nontreated control. The conventional herbicide program reduced seed production by greater than 99%. Averaging both spacings the early clipping reduced seeds by 48%, and the late clipping by 50%. The results indicate that clipping above the soybean canopy may be a valid strategy to reduce Palmer amaranth seed production, especially in fields with several Palmer amaranth escapes or where plants are too large for effective control by a label herbicide application.

61 - Effect of row spacing and overlapping residual herbicide programs on control and seed production of Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus*) in irrigated soybean

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Palmer amaranth (*Amaranthus palmeri* S. Watson) and waterhemp [*Amaranthus tuberculatus* (Moq.) J.D. Sauer] are the most troublesome weeds in soybean [*Glycine max* (L.) Merr.] in the North Central United States. Both have evolved resistance to most foliar-active postemergence herbicides. Overlapping residual herbicides and narrow rows may extend control, but their combined effects are unknown. Therefore, the objective of this study was to evaluate the effect of row spacing and overlapping residual herbicide programs on Palmer amaranth and waterhemp control, photosynthetically active radiation (PAR) interception, seed production, and soybean yield. The study was conducted in Iowa, Illinois, Minnesota, Missouri, Nebraska, and Wisconsin in 2026. The experiment was a split-block design with four replications. Row spacing (38 and 76 cm) was the strip factor. Eight herbicide programs, including a weed-free check, were randomized within each strip. All plots received flumioxazin + metribuzin + pyroxasulfone (88 + 263 + 112 g ai ha^{-1}) as a preemergence herbicide applied at planting (PRE). The PRE

was applied alone or followed by a residual herbicide applied early postemergence (RHAEP; V1 to V3 soybean), a residual herbicide applied late postemergence (RHALP; V3 to V5 soybean), or both. The RHAEP was S-metolachlor (1,424 g ai ha^{-1}) or dimethenamid-P (1,103 g ai ha^{-1}). The RHALP was acetochlor (1,681 g ai ha^{-1}) or pyroxasulfone (128 g ai ha^{-1}). Weed control, density, PAR, seed production, and soybean yield were recorded. Palmer amaranth predominated in Nebraska and waterhemp in the other states. Data were analyzed in R using a generalized linear mixed model. Averaged across five states, waterhemp control 56 d after RHALP was 75% with the PRE alone. Control increased to 84% with RHAEP or RHALP and 90% with RHAEP followed by RHALP ($P = 0.028$). RHAEP followed by RHALP improved control over the PRE alone in Illinois (93% vs 84%), Minnesota (95% vs 48%), and Missouri (72% vs 53%). Herbicide programs did not differ in Iowa and Wisconsin, where the PRE alone controlled waterhemp ≥92%. RHAEP followed by RHALP also reduced waterhemp density at RHALP from 7.7 to 1.6 plants m^{-2} ($P < 0.001$). Row spacing did not affect waterhemp control ($P = 0.37$). However, soybean in 38-cm rows intercepted more PAR than in 76-cm rows in Minnesota (74% vs 38% at V6), Nebraska (62% vs 25% at 66 d after planting), and Wisconsin (45% vs 14% at V5) ($P \leq 0.014$). Seed production did not differ among treatments ($P \geq 0.32$). However, RHAEP followed by RHALP reduced waterhemp seed production by 88% to 91% compared with the PRE alone in Minnesota and Wisconsin. Soybean yield in Illinois and Wisconsin did not differ between row spacings ($P = 0.14$) or among herbicide programs ($P = 0.42$). These results demonstrated that overlapping residual herbicides extended waterhemp control where weed pressure was high. Narrow rows increased canopy light interception but did not improve control or yield.

62 - Modeling Leaching Potential of Variable Rate PRE Flumioxazin and Imazapic Applications Based on Cover Crop Biomass Accumulation.

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Across the southeast, an increasing number of growers are implementing cover crops into their crop rotations which may suppress summer annual weeds when enough biomass accumulation occurs. This may reduce the need for preemergent herbicide applications, saving growers money and reducing the potential of herbicide leaching. Cover crop biomass accumulation is often variable throughout a field, resulting in some areas having enough to suppress weeds and while others not, potentially requiring additional herbicide applications. With modern smart sprayer technologies and cover crop biomass predictions, it may be possible to develop variable rate herbicide applications based on cover crop biomass accumulation, resulting in herbicide savings compared to broadcast applications. To simulate potential herbicide savings and leaching effect at three, six and twelve months after application at a depth of 7.5-cm, we utilized a previously calibrated HYDRUS model on leaching of imazapic and flumioxazin at four NC locations (a, b, c, d) based on interpolated cereal rye biomass. As a tradeoff exists between herbicide savings and efficacy, three levels of prescription map intensities (low, variable and high) were developed for each herbicide and location that varied in their biomass accumulation thresholds for different herbicide rates. Interpolated cereal rye biomass values ranged from 0 to 8312 kg ha^{-1} providing

ample variation in biomass between the four locations. Three of the four locations showed flumioxazin savings between 4.4 and 24.5 g a.i. ha^{-1} for the variable scenario when compared to a 1x application, while only field c remained below the 1x threshold for imazapic for the same scenario saving 12 g a.i. ha^{-1}. Simulated herbicide residues at 3, 6, and 12 months after application were compared to known *Brassica carinata* A. Braun (carinata) ID_{25} values in a sandy and loamy sand soil based on a previous study. Flumioxazin residue was below the carinata ID_{25} for all locations, soil types and scenarios 6 months after treatment. At three months the loamy sand soils showed all flumioxazin residues below the LD_{25}, while in the sandy location, residues remained greater than the LD_{25} for 3 out of 4 locations. Imazapic also showed lower overall residues in loamy sand soils compared to the sandy soils but remained above the carinata LD_{25} through 9 to 12 months after treatment in some scenarios. In conclusion, herbicide savings could be more easily achieved with flumioxazin compared to imazapic when enough cover crop biomass accumulation occurs. Additionally, growers should be aware of a greater chance of carinata injury in sandy soils compared to loamy sand if applications occurred less than 3 months before cover crop planting.

63 - Impact of Soybean Preemergence Herbicides on Fall Establishment of Alternative Cover Crops

Breawna Smith[1], Ryan DeWerff[1], Guilherme Chudzik[1], Anastasia Kurth[1], Will Fulwider[1], Dan Smith[1], Sam Bibby[1], Rodrigo Werle[1]

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Cover crops are increasing in popularity and planted acres across the U.S. North Central Region as they can provide agronomic and environmental benefits such as reduced erosion, improved nutrient cycling, increased soil organic matter, and/or weed suppression. Though cereal rye (*Secale cereale* L.) has historically been the predominant cover crop adopted in Wisconsin and across the North Central region, diversification of cover crop species may provide additional benefits and greater flexibility for growers, particularly ahead of corn. However, the successful integration of alternative cover crops may be limited by carryover from herbicides applied to the preceding crop(s). The objective of this study is to evaluate the effects of carryover from common spring applied preemergence herbicides used in soybean production on the fall establishment and growth of hairy vetch (*Vicia villosa* Roth) and camelina (*Camelina sativa* L.). A replicated field experiment was established to evaluate the potential carryover injury of 11 preemergence herbicides commonly used in Wisconsin soybean production. Herbicide treatments consisted of products with single site of action (SOA) as well as premixes with more than one SOA (cloransulam-methyl, metribuzin, flumioxazin, fomesafen, sulfentrazone, acetochlor, pyroxasulfone, S-metolachlor, flumioxazin+pyroxasulfone, sulfentrazone+S-metolachlor, and metribuzin+flumioxazin+pyroxasulfone). Herbicide application occurred on May 14, 2026. Camelina was planted at 8.4 kg ha-1 at a depth of approximately 0.6 cm and hairy vetch was planted at 25.8 kg ha-1 at 1.25 cm on August 26 using a Great Plains 3P606 NT drill. The experiment was conducted on bare-ground plots to allow earlier cover crop establishment than would typically be possible following soybean harvest, thereby increasing the likelihood of detecting herbicide carryover effects and providing a more conservative assessment of potential carryover injury. Hairy vetch and camelina response to each herbicide was characterized through comparing stand counts collected 16 days after planting. Preliminary

results from the first year of our experiment show that camelina emergence was reduced by up to 92% and 75% because of fomesafen and sulfentrazone carryover, whereas hairy vetch emergence was not impacted by any of the treatments evaluated. Results from this research will help characterize the sensitivity of camelina and hairy vetch to commonly used soybean herbicide programs and identify potential rotational restrictions and management considerations for growers interested in incorporating these cover crop species into their cropping systems.

64 - Community Composition, Not Diversity, Affect Weed Biomass in a Perennial Forage System.

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Perennial forage crops can disrupt annual weed life cycles, thereby decreasing the abundance of annual weeds. However, the extent to which forage community composition and diversity influence weed suppression during the establishment year remains unclear. This period is important because perennial forages are vulnerable to weed competition before stands mature, and successful establishment is critical to long-term stand persistence and quality. We evaluated the effects of perennial forage community composition and diversity on weed biomass during the first year of establishment. We hypothesized that weed biomass would decrease with increasing forage diversity and that forage community composition would influence weed biomass. Six perennial forage species representing three functional groups were established as six monocultures and five mixtures in a two-year rotation across two planting entries. The species included alfalfa (*Medicago sativa*), birdsfoot trefoil (*Lotus corniculatus*), orchardgrass (*Dactylis glomerata*), tall fescue (*Lolium arundinaceum*), forage chicory (*Cichorium intybus*), and small burnet (*Sanguisorba minor*). Forage and weed biomass were collected at the end of the establishment years. Forage community composition influenced weed biomass, whereas diversity did not. Among monocultures, birdsfoot trefoil had the largest weed biomass, while forage chicory had the lowest across both planting entries. Forage mixtures did not differ significantly from monocultures, suggesting that increasing forage diversity alone did not improve weed suppression during establishment. These findings indicate that forage species identity, rather than diversity alone, plays an important role in weed suppression during the establishment year. Forage chicory may be an option for suppressing weeds during this critical period. Future research should investigate the mechanisms contributing to chicory's weed-suppressive effects and evaluate its potential to improve weed management and perennial stand establishment. While we found no effect of diversity on weed suppression in the establishment year, future research will examine how forage community composition and diversity influence weed suppression in mature forage stands.

65 - Cereal Cover Crop Termination Time Influences Weed Control and Yield in Truvera Sugarbeet

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Cover crops can reduce soil erosion, increase soil organic matter and water infiltration, and suppress weeds. Truvera sugarbeet (*Beta vulgaris* L.), which permits in-crop applications of glyphosate, glufosinate, and dicamba, may create opportunities to integrate cover crops and reduced-till practices into sugarbeet production. Field experiments were conducted at three Michigan locations to evaluate the effects of cereal cover crops terminated at different times for weed control and yield in no-till Truvera sugarbeet. The trial was setup in a split-plot design with cover crop as the main plot: wheat (*Triticum aestivum* L.), cereal rye (*Secale cereale* L.), and triticale (*X Triticosecale* W.), and termination treatment at the sub plot, termination at sugarbeet planting with or without a PRE residual program, at 14 d after planting, and at 2-leaf sugarbeet. No cover non-treated and weed-free controls were also included for comparison. Cover crops were seeded in fall 2025 at 67 kg ha^{-1} with a grain drill, with tubes over planned sugarbeet rows plugged to leave unseeded planting strips. Cover crops were terminated with 1.26 kg ae ha^{-1} glyphosate. The PRE residual treatment consisted of dicamba at 0.56 kg ha^{-1} + ethofumesate at 1.68 kg ha^{-1}. All cover crop-termination combinations received glyphosate + glufosinate POST at the 2- and 6- to 8-leaf sugarbeet stages, followed by glyphosate at the 12-leaf stage. At the 2-leaf evaluation, waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] control was 87-100% when termination was delayed past planting or a PRE was included, but only 23% when cover crops were terminated at planting without a PRE. At the 6- to 8-leaf sugarbeet stage, waterhemp control was highest when cover crops were terminated at planting with a PRE (97%) or at the 2-leaf stage (99%), compared with termination at planting without a PRE (90%). Horseweed (*Erigeron canadensis* L.) control exceeded 97% across termination treatments at two locations. At the third location, control was 33% with planting-time termination without PRE but exceeded 97% when PRE was included or termination was delayed. Annual grass (Poaceae spp.) and common lambsquarters (*Chenopodium album* L.) control followed similar trends as horseweed. Sugarbeet stand was reduced by 26 and 52% when cover crop termination was delayed until 14 d after planting and the 2-leaf sugarbeet stage, respectively. Reduced stands contributed to lower sugarbeet root yields, which were 44-76% lower when cover crop termination was delayed until the 2-leaf stage compared with treatments terminated at planting. Root yield did not differ among cover crop species. In conclusion, cereal cover crops provided early-season weed suppression, with termination timing influencing weed control. However, delaying cover crop termination beyond sugarbeet planting reduced sugarbeet stand and subsequent root yield. These results demonstrate the potential for Truvera sugarbeet to create new opportunities for incorporating cover crops and reduced-tillage practices into sugarbeet production systems.

66 - Weed Management And Residual Herbicide Optimization In Wheat-Soybean Relay Intercropping Systems.

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[1]Kansas State University, [2]University of Arkansas

Two studies compared weed control, herbicide programs, and grain yield in soybean [*Glycine max* (L.) Merr.] monoculture and relay intercropping with wheat (*Triticum aestivum* L.).

Wheat was planted April 11, 2025; relay and monoculture soybean were planted May 6 and May 27, 2026, respectively. Study 1 evaluated full-season weed management. Monoculture received paraquat plus flumioxazin and pyroxasulfone (0.070 + 0.089 kg ai ha^{-1}) on May 6. Relay received pyroxasulfone (0.15 kg ai ha^{-1}) on November 7, 2025, followed by pinoxaden plus fenoxaprop-P-ethyl (0.060 + 0.030 kg ai ha^{-1}) on March 20, 2026. Soybean postemergence (POST) programs were no POST, glyphosate (1.35 kg ae ha^{-1}) plus 2,4-D (1.06 kg ae ha^{-1}), or that mixture plus S-metolachlor (1.80 kg ai ha^{-1}). All POST mixtures included AMS (2.5% v/v). POST applications occurred June 8 in monoculture and June 23 in relay, at wheat harvest. Study 2 compared flufenacet plus metribuzin (0.22 + 0.056 kg ai ha^{-1} in monoculture; 0.34 + 0.084 in relay), pyroxasulfone at 0.18 kg ai ha^{-1} in both systems, and pyroxasulfone at 0.28 kg ai ha^{-1} in monoculture or 0.15 kg ai ha^{-1} in relay. Experiments used randomized complete block designs with four replications. Visual ratings assessed overall weed control rather than species-specific control. Overall control and soybean yield were analyzed with cropping system, herbicide program, and interaction as fixed effects and block as random. Assessment dates were analyzed separately. Final weed counts used negative-binomial mixed models with a log link and random block. Estimated marginal means used Tukey-adjusted pairwise comparisons; system contrasts within programs used Holm adjustments ($\alpha = 0.05$). Wheat yield was compared only among relay programs. Yields were expressed at 13% moisture. In Study 1, herbicide affected final overall weed control ($P = 0.0053$), whereas system and interaction did not ($P = 0.1913$ and 0.0710). Averaged across systems, POST programs with and without S-metolachlor both provided 84% control versus 62% without experimental POST ($P = 0.0053$). Final weed counts showed an interaction ($P = 0.0007$). Herbicides did not differ within monoculture; observed relay densities with and without S-metolachlor were 0.04 and 0.14 plants m^{-2} versus 1.03 without POST. In Study 2, final overall control averaged 85% in monoculture and 70% in relay ($P = 0.0042$); herbicide and interaction effects were not detected. Soybean yield was numerically greatest in monoculture with residual POST in Study 1 (2.68 Mg ha^{-1}) and higher-rate pyroxasulfone in Study 2 (3.19 Mg ha^{-1}), without significant system, herbicide, or interaction effects (all $P \geq 0.1263$). Wheat yields ranged from 1.48 to 1.54 Mg ha^{-1} in Study 1 ($P = 0.9872$) and 0.79 to 1.24 Mg ha^{-1} in Study 2 ($P = 0.0522$).

POST programs improved final overall weed control, while grain-yield differences were not detected.

67 - Innovative Cropping Systems for Managing Palmer amaranth (*Amaranthus palmeri*), Arthropods, Diseases and Soil Health in the Central US Great Plains

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Palmer amaranth is a problem weed species in Midwestern cropping systems. It has evolved resistance to multiple herbicide sites of action, and this, combined with high fecundity, complicates its management. Integrated weed and pest management strategies are warranted to address this issue. Innovative cropping systems need to be designed and evaluated to suppress Palmer amaranth, prevent end-of-season seed rain, enhance favorable arthropod abundance and reduce disease incidence. This study evaluates five cropping systems: Corn-Soybean, Corn-cereal rye-soybean, winter wheat-fallow-soybean, winter wheat-cereal rye-soybean and winter wheat -broadleaf cover crop. The study utilizes a randomized complete block design

with five replicates conducted at South Central Ag Lab, NE. Objectives include evaluating the effects of different cropping systems on Palmer amaranth density, assessing arthropod community composition, and disease incidence. We hypothesize that diversified cropping systems will contribute significantly to suppressing Palmer amaranth emergence, disease prevalence, maintaining favorable arthropod community, and increasing overall production profitability compared with simplified cropping systems.

68 - Triticale Cover Crop Termination with Herbicide Programs Containing Epyrifenacil.

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Triticale (× Triticosecale Wittm.) can be used as an alternative to cereal rye cover crop in soybean production systems to protect the soil, suppress weeds, and contribute to soil conservation. However, timely termination is essential to minimize potential interference with soybean establishment. Herbicide programs that provide rapid and effective triticale control may be particularly beneficial when soybeans are planted at or near the time of cover crop termination. The objective of this study was to evaluate the speed and efficacy of triticale termination with herbicide programs containing epyrifenacil and other standard burndown active ingredients in combination with glyphosate.

A field experiment was conducted in 2026 at a Kansas River Valley Experiment Field near Rossville, Kansas. Treatments were arranged in a randomized complete block design with four replications, and plots measured 3 × 9 m. Herbicides were applied 7 days before soybean planting. Glyphosate was applied at 1,261 g ae ha^{-1} in each herbicide treatment combined with 2,4-D (1,065 g ae ha^{-1}), saflufenacil (25 g ai ha^{-1}), epyrifenacil (20 g ai ha^{-1}), epyrifenacil + flumioxazin (20 + 87.4 g ai ha^{-1}), or flumioxazin + pyroxasulfone + epyrifenacil (88.3 + 90.4 + 21.0 g ai ha^{-1}). Appropriate adjuvants were added according to treatment requirements. A nontreated control was included. Triticale control was visually assessed on a scale from 0 (no control) to 100% (complete control) at 3, 7, 10, 14, 21, and 28 days after treatment (DAT). Data were subjected to analysis of variance (ANOVA) in R, with treatment and replication included in the model. Residual normality and homogeneity of variances were assessed using Shapiro-Wilk and Levene’s tests, respectively. Treatment means were compared using Tukey’s HSD test at a 5% significance level.

Herbicide programs differed primarily in the rate of triticale termination. At 3 DAT, epyrifenacil-containing programs provided 43 to 55% control compared with 30 to 38% for standard burndown programs. At 7 DAT, epyrifenacil-containing programs provided 85 to 86% control, which was greater than glyphosate + 2,4-D (63%) and glyphosate + saflufenacil (59%). This difference persisted at 10 DAT, when epyrifenacil-containing programs achieved 89 to 95% control compared with 70 to 74% for the standard programs. By 14 DAT, all herbicide treatments provided at least 98% control, with no significant differences among herbicide programs. Similar levels of control were maintained through 28 DAT.

Overall, herbicide programs containing epyrifenacil resulted in greater triticale control compared with standard burndown programs at 7 and 10 DAT. However, all herbicide treatments provided similar levels of control by 14 DAT. These findings suggest that epyrifenacil-containing programs may be valuable when rapid triticale termination is desired before soybean planting.

69 - Evaluation of Inter-planting Soybeans for Early Season Weed Control

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The increase of herbicide resistant weeds threatens the sustainability of weed management in U.S soybean [*Glycine max* (L.) Merr.] production systems. Inter-planted soybeans could improve weed management through crop shading and earlier canopy closure. Field experiments were conducted in 2025 and 2026 to evaluate the effects of inter-planted soybean row spacing, herbicide programs, and termination timing on weed suppression and soybean yield. Inter-planted soybeans were established at 741,000 plants ha^{-1} in 0.19- or 0.38-m row spacings by alternating dicamba-resistant and 2,4-D-resistant varieties. Herbicide programs included a pre-emergence (PRE)-only application of S-metolachlor (622 g ha^{-1}) + metribuzin (148 g ha^{-1}), or this same PRE treatment followed by a post-emergence (POST) application of glyphosate (127 g ha^{-1}) + glufosinate (50 g ha^{-1}). Standard practice controls consisted of soybeans planted at 370,000 plants ha^{-1} in 0.38- or 0.76-m rows that received PRE followed by POST herbicides. Inter-planted 2,4-D-resistant soybean were eliminated with dicamba (226 g ha^{-1}) at flowering (R1) or pod expansion (R4), resulting in a final population of 370,000 plants ha^{-1}. Additional herbicide-free treatments included in 2026 evaluated manual termination of inter-planted rows. Termination at R1 generally resulted in lower weed densities than termination at R4, although significant differences occurred only in some treatments. In both years, weed densities in termination treatments were statistically equivalent to standard practice controls. In 2025, inter-planted soybeans in 0.38-m rows terminated at R1 with either PRE-only (3,011 kg ha^{-1}) or PRE followed by POST (3,049 kg ha^{-1}) herbicide programs produced yields that were statistically equivalent to the standard practices. In 2026, standard practice soybeans planted at 0.38-m spacing produced the highest yield (4,287 kg ha^{-1}), but yields from inter-planted soybean terminated at R1 were statistically equivalent. In both years, termination at R4 resulted in a significant yield loss. Inter-planted soybean systems terminated at R1 have the potential to enhance canopy closure while also maintaining yield.

70 - Comparison of Conventional and Alternative Weed Management Strategies in Soybean.

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The use of autonomous robotic weeding shows promise as a potential new method of weed control; however, limited research has been conducted to evaluate its efficacy compared with conventional weed management practices. In 2026, Greenfield Robotics’ Botony robot was evaluated as part of a study comparing eight conventional and alternative weed management strategies. Robotic mowing treatments were implemented throughout the season when weeds reached 10 cm in height. Visual weed control and

weed densities were evaluated throughout the growing season, and soybean yield was assessed at harvest. The weeds present included waterhemp, foxtail, cocklebur, and shattercane. Visual weed control near the end of the growing season ranged from approximately 96 to 98% across the various management strategies. The PRE followed by robotic mowing treatment provided 97% visual weed control and resulted in weed densities of 5 weeds/m² near the end of the growing season, which were not significantly different from the standard PRE followed by POST herbicide program (1 weed/m²). However, tillage followed by robotic mowing resulted in significantly higher weed densities (7.5 weeds/m²) than the standard herbicide program. Inter-row cultivation throughout the season and planting green into cereal rye with a subsequent herbicide program also resulted in 98% weed control and weed densities of 2.5 and 0 weeds/m², respectively. All of the alternative weed management strategies except tillage followed by robotic mowing resulted in soybean yields that were statistically similar to the standard PRE followed by POST herbicide program. These results indicate that alternative weed management strategies such as inter-row cultivation and planting green into cereal rye can provide weed control comparable to conventional herbicide programs, while the effectiveness of robotic mowing may depend on the management practices used in combination with this technology.

71 - Controlling Waterhemp (*Amaranthus tuberculatus*) Using Novel Cover Crop, Herbicide, and Tillage Management Strategies in Soybeans

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Waterhemp (*Amaranthus tuberculatus* (Moq.) J.D. Sauer) presents a persistent management challenge in soybean (*Glycine max* (L.) Merr.) production due to prolonged emergence and resistance to multiple herbicide sites of action. Recent herbicide mitigation requirements associated with the Endangered Species Act (ESA) have increased the importance of identifying weed management practices that reduce potential environmental impacts while maintaining effective weed control and crop productivity. Conservation practices, including cover crops and reduced tillage, may contribute to runoff and erosion mitigation, while banded herbicide applications can reduce the total area treated. However, the effectiveness of combining these practices for herbicide-resistant waterhemp management remains uncertain. A field experiment was conducted during 2025-2026 at the Southern Illinois University Agronomy Research Center in Carbondale, Illinois, to evaluate the effects of cereal rye (*Secale cereale* L.) establishment, tillage, and preemergence (PRE) herbicide strategies on waterhemp control and soybean productivity. A split-split-plot factorial experiment with four replications evaluated three cereal rye treatments (no rye, one drilled pass at 67.3 kg ha^{-1}, or two perpendicular passes totaling 67.3 kg ha^{-1}), two tillage systems (no-till and strip-till), and three PRE herbicide strategies (no PRE, banded, or broadcast application of Fierce XLT, (Chlorimuron 21.5 g ai ha^{-1} + Flumioxazin 79.2 g ai ha^{-1} + Pyroxasulfone 100.5 ga ai ha^{-1}). Cereal rye was terminated before soybean planting, and all plots received a common broadcast postemergence (POST) application of glufosinate + acetochlor at 448.34 and 1,266.56 g ai ha^{-1}. Weed density, biomass, visual control, and soybean yield were evaluated. Data were

analyzed using linear mixed models with Tukey-adjusted mean comparisons (α = 0.05). Before PRE application, waterhemp density averaged 1.13 plants 0.5 m^{-2} without rye and zero in both rye treatments (cover-crop effect P = 0.034), although pairwise comparisons did not separate treatments. At 21 days after PRE application, waterhemp control was 76.6%, 86.9%, and 90.7% for no rye, one-pass rye, and two-pass rye, respectively (P = 0.0089). At 21 days after POST application, corresponding control ratings were 47.6%, 69.8%, and 76.2% (P = 0.002). PRE herbicide strategy significantly affected waterhemp density before POST application (P = 0.002), with 7.54, 3.67, and 0.29 plants 0.5 m^{-2} for no PRE, banded PRE, and broadcast PRE, respectively. At 21 days after POST application, broadcast PRE provided 90.5% waterhemp control compared with 54.0% for banded PRE and 49.1% without PRE (P < 0.001). Strip-till improved waterhemp control at 21 days after PRE application but not consistently across assessment timings. Soybean yield did differ by cereal rye treatment (P = 0.012). Yield in the two-pass rye was greater than one-pass (2,092 kg ha^{-1} vs 1,823 kg ha^{-1}), but was not different than no rye (2,001 kg ha^{-1}). These first-year results indicate that cereal rye may complement residual herbicide programs, but banded PRE applications did not provide waterhemp control equivalent to broadcast applications. Integrating conservation practices with effective residual herbicide programs may support ESA mitigation objectives while maintaining soybean productivity, although additional research is needed to determine the consistency of these responses across environments.

72 - Effect of Spring-Planted Cover Crop Termination Timing and Herbicides on Weed Control in Corn

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Multiple herbicide-resistant weeds highlight the need for non-chemical weed management strategies. Challenges associated with establishing fall-planted cover crops in temperate regions necessitate alternative approaches. This study evaluated spring-planted cover crops, termination timing, and postemergence (POST) herbicides for weed management in corn. A field experiment was conducted in 2026 at South Dakota State University Southeast Research Farm near Beresford, South Dakota. Treatments were arranged in a split-split-plot randomized complete block design with four replications. Main plots included four cover crop treatments: no cover crop, oats (*Avena sativa* L.), peas (*Pisum sativum* L.), and an oat-pea mixture (40:60 ratio), all seeded at 78 kg ha^{-1}. The subplot factor consisted of five cover crop termination timings: 7 days before corn planting (T1), at corn planting (T2), 14 days after corn planting (T3), 28 days after corn planting (T4), and 35 days after corn planting (T5). The sub-subplot factor consisted of two POST herbicide treatments: with or without a tank mixture of atrazine (1,121 g ai ha^{-1}), mesotrione (105 g ai ha^{-1}), and glyphosate (1,260 g ae ha^{-1}). Cover crops were drilled one month before corn planting and terminated using glyphosate (1,260 g ae ha^{-1}). Cover crop biomass was measured at termination, whereas total weed density and biomass were recorded at cover crop termination and at monthly intervals until corn harvest. Data were analyzed using the GLIMMIX procedure in SAS. Dry biomass of oats, peas, and the oat-pea mixture ranged from 356 to 4,751 kg ha^{-1}, 260 to 1,726 kg ha^{-1}, and 272 to 2,612 kg ha^{-1}, respectively. At T3 termination, total weed density was 50%, 25%, and 33% lower with oats, peas, and the oat-pea mixture, respectively, compared with the no cover crop treatment. Total weed biomass was reduced by >90% with each cover crop treatment compared with the no cover crop

treatment. Averaged across cover crop treatments, the addition of POST herbicides reduced the total weed density by 3% and weed biomass by 8% compared with no POST herbicides. These results highlight the potential of spring-planted cover crops integrated with POST herbicides as an effective approach for improving weed management in corn production systems.

73 - Integrating Cover Crop Mixes and Residual Herbicides for Weed Control Before Late-Planted Corn

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Cereal rye (*Secale cereale* L.) cover crop (rye CC) suppresses weeds but can reduce the yield of a subsequent corn crop. Cover crop (CC) mixtures may mitigate this disadvantage but provide less weed suppression, which integrated herbicide programs may compensate for. The objective was to evaluate the effects of CC treatments and herbicide program integration for weed suppression, yield, and economic returns in late-planted corn, compared with traditional chemical fallow and rye CC. An on-farm study in 2025 and 2026 near Oak Hill, KS, evaluated rye CC and three blends of hairy vetch (*Vicia villosa* Roth; HV) and triticale (×*Triticosecale* Wittm. ex A. Camus; Tr), each terminated with glyphosate + 2,4-D alone (burndown only) or with flumioxazin (burndown + residual), plus a chemical fallow control, before late-planted corn (*Zea mays* L.). Rye CC produced the most biomass in 2025 but the least in 2026, when a warm spring advanced its termination, whereas the triticale-HV CC treatments produced similar biomass across seeding rates and years. Winter weed suppression increased with the cereal proportion of the CC, but no CC treatment suppressed cheatgrass (*Bromus tectorum* L.). Summer weed suppression at corn planting depended on weather, CC biomass, and the dominant weed species. Adding the residual herbicide reduced summer weed infestation relative to burndown only, but its effect varied with rainfall for activation and the target species. In the drier 2025 season, dominated by velvetleaf (*Abutilon theophrasti* Medik.), all CC treatment and herbicide program combinations reduced summer weed biomass by 97% and weed cover by more than 99% on average relative to chemical fallow. In the wetter 2026 season, dominated by Palmer amaranth (*Amaranthus palmeri* S. Watson), only the triticale-HV CC treatments with burndown + residual, which received activating rainfall soon after application, consistently reduced weed cover and biomass (53 to 95%) relative to chemical fallow, whereas rye CC did not differ from chemical fallow. Corn yield was available only for 2025, when all CC treatments yielded 25 to 35% less than chemical fallow (7,470 kg ha^{-1}), regardless of herbicide program, and the triticale-HV CC treatments did not differ from rye CC. With lower yield and \$107 to \$192 ha^{-1} greater direct costs, the CC treatments had \$524 to \$609 ha^{-1} less gross margin than chemical fallow (\$1,372 ha^{-1}) in 2025. Integrating triticale-HV CC treatments with a residual herbicide provided the most consistent summer weed suppression across years, but before late-planted corn, this benefit came with a yield and economic penalty relative to chemical fallow in 2025.

74 - Utilizing Multispectral Imagery to Evaluate Cover Crop Growth and Weed Suppression

Steven Tri[1], Estefania Polli[1], Fernando Marcos[1], Rocco D'Antico[1], Ethan Easter[1], Caroline Backes[1], Tunde Akanbi[1], Iththiphonh Macvilay[1], Damian Franzenburg[1], Mark Licht[1], Wesley Everman[1]

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Cereal rye (*Secale cereale*) cover crops have been traditionally adopted in soybean (*Glycine max*) production systems to improve soil health and control erosion. More recently, their use for weed suppression has gained interest. However, information on how cereal rye growth, biomass accumulation, and termination timing affect weed suppression is still limited. Assessing these factors and their relationship is therefore essential to understanding their effect on weed suppression. Traditional field measurements provide valuable information, while imagery-based measurements can complement these assessments by capturing spatial patterns in cereal rye growth and weed suppression. Thus, this study evaluated the use of imagery-based measurements to assess cereal rye growth and weed suppression in soybean, using field measurements as a reference. A field experiment was conducted at Curtiss Farms in Ames, Iowa, in 2026. Treatments were arranged in a 2 x 2 x 5 factorial design with four replications. Factors included two soybean row spacings (38.1 and 76.2 centimeters), two weed management systems (weed-free and weedy), and five termination timings (7 days prior to planting, at planting, 7 days after planting,14 days after planting, and no-cover control). Multispectral drone imagery was collected and processed by the Iowa State University Remote Sensing & Imaging Lab (RSIL) to measure cover crop growth and weed suppression. Data analyses were still in progress at the time of abstract submission.

75 - Can Delayed Cover Crop Termination and Rolling Improve Weed Suppression Compared to Winter Fallow?

Michael Flessner[1], Mark VanGessel[2], John Wallace[3], Kurt Vollmer[4]

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Early soybean planting has become popular, but optimizing integrated weed management within these early-planted systems remains critical, especially for *Amaranthus* species. Greater cereal rye (*Secale cereale*) biomass enhances weed suppression, while an actively growing green canopy suppresses germination cues via light filtering and direct competition. Given that soybeans can tolerate rolling up to the V3 stage without yield loss, terminating cereal rye after soybean emergence may extend the cover crop growing season and optimize weed suppression. Consequently, the objective of this research was to determine the feasibility and optimum timing for cereal rye termination and rolling after soybean emergence to maximize weed suppression while maintaining or improving crop yield. Research was conducted at field sites in Virginia, Pennsylvania, and Maryland in 2026. Treatments included cereal rye termination via herbicide (glyphosate + glufosinate) or herbicide + roller crimper at soybean planting, V1, V2, and V3 soybean growth stages. Two check treatments were also included: a no cover crop, preemergence followed by postemergence herbicide control ("standard-practice") and a no cover crop, postemergence herbicide only check ("POST-only"). Cereal rye biomass, weed density, and visually rated

soybean injury data were collected at termination for each treatment and at postemergence herbicide application, which was glyphosate + glufosinate + 2,4-D + *S*-metolachlor applied across the entire study at V5 to V6 soybean. Maryland did not have significant weed pressure and was thus not included in the analysis. Cereal rye biomass increased with termination timing. Amaranthus species density at V1, V2, and V3 terminations was less than the POST-only check, suggesting that delaying termination until after planting is beneficial. Somewhat similarly, summer annual grass density was less than the POST-only check at the V1 and V2 terminations. When evaluated at the postemergence herbicide application, weed density (*Amaranthus* species and summer annual grass) was generally least at the V1 to V2 terminations, and weed control was similar to the standard-practice check for all treatments except at planting termination. Termination method (herbicide versus herbicide + roller crimper) did not influence weed density or control. However, roller crimping resulted in more soybean injury than not. Termination timing did not influence soybean injury. Soybean yield decreased as termination time increased in Pennsylvania, but the opposite trend occurred in Maryland. Across sites, only termination at V3 with the roller crimper resulted in less yield than the standard-practice check. These data indicate that delaying cereal rye termination until after soybean emergence is feasible and can result in better weed suppression than termination at planting.

76 - Can yield zone stability maps inform zone-based IWM?

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Weed populations are characterized by high spatial variability within and among agricultural fields due to complex interactions between biotic, abiotic, and management-driven processes that select for adapted traits in weed species. Our discipline’s challenge is to design IWM strategies that are informed by knowledge of biotic, abiotic, and management-driven processes to reduce reliance on herbicide-based weed control. This challenge requires greater emphasis on aligning IWM with agroecological principles and eco-evolutionary dynamics. Weed survival to control tactics (e.g., weed escapes) shapes ecological and evolutionary outcomes, such as herbicide resistance. Emerging sensor technologies can be leveraged to generate a greater understanding of weed survival in response to ecological- (cash crops, cover crops), chemical- (herbicides), and environmental stressors in corn-soybean production systems. Methods have been developed to identify crop management zones using multiple years of harvest data from harvest equipment. This approach facilitates zone-based fertility or crop management by identifying areas that are either high- or low- yielding, and temporally stable or unstable. Yield-limiting factors may include temporally stable abiotic processes (e.g., soil-texture, depth) or temporally unstable abiotic (e.g., water or nutrient limitation) or biotic (e.g., pest incidence) processes. Yield stability zone mapping presents an established method for informing zone-based IWM when integrated with high-resolution weed distribution data. In preliminary analysis of commercial data, we found that the location of weed escapes, predicted from as-applied maps generated by targeted spray technologies (e.g. See & Spray™), are positively correlated with low and stable yield zones. Previous studies have shown that recurrent exposure to sub-lethal herbicide doses can result in weed populations that exhibit a lower response to herbicide after a few generations due to phenotypic plasticity. Integration of precision sprayer data and machine-vision technologies capable of species recognition presents an unexplored opportunity to identify sub-

field zones with greater risk of low-dose selection events. Using as-applied maps for pre-plant burndown and soil-residual applications, we found that irregular-shaped fields result in predictable spray patterns. Locations where applied rates were lower than targeted rates (e.g. “low dose”) were positively correlated with weed escapes, which were predicted from as-applied maps. In summary, our preliminary analysis suggest that crop yield stability and as-applied maps could be used to identify zones that can be targeted with cultural management (cash- or cover-crop) or targeted control (chemical- or non-chemical) tactics in a site-specific framework.

77 - Non-Chemical Weed Management Tools Influence In-Season Weed Density and Subsequent Weed Emergence in Soybean.

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Increasing herbicide resistance has renewed interest in nonchemical weed management strategies for soybean (*Glycine max* [L.] Merr.). Field experiments conducted in Aurora, NY, during 2024 and 2025 compared inter-row mowing (IRM), electrocution (EWC), seed impact mill (SIM), sequential IRM followed by EWC and SIM, glufosinate plus 2,4-D choline, and a nontreated control (NTC) for in-season weed density and subsequent spring weed emergence. Treatments were maintained on the same plots across years. The POST herbicide treatment provided the greatest weed suppression in both years. In 2024, IRM reduced between-row common ragweed (*Ambrosia artemisiifolia* L.) and foxtail (*Setaria* spp.) densities by 94% and 70%, respectively, relative to NTC at 10 weeks after planting (WAP). EWC resulted in 75% lower common ragweed density but did not significantly affect foxtail spp. Sequential management decreased within-row foxtail spp. density by 50% compared with EWC and 67% compared with IRM. At 10 WAP, IRM and sequential management reduced total weed density between soybean rows by 78% and 83%, respectively, compared with NTC, whereas EWC reduced within-row total weed density by 45%. In 2025, sequential management had 50% lower between-row foxtail spp. density than IRM. At 10 WAP, IRM, EWC, and sequential management reduced total weed density between soybean rows by 56%, 67%, and 78%, respectively, compared with NTC. After two growing seasons, sequential management reduced spring emergence of common ragweed, common lambsquarters (*Chenopodium album* L.), and foxtail spp. by 96%, 88%, and 67%, respectively, compared with NTC. SIM alone did not improve weed suppression or subsequent emergence. Despite herbicide effectiveness, IRM and EWC offer complementary options for managing herbicide-resistant weeds, depending on weed species composition and management costs.

78 - Investigating Summer Cover Crops for Italian Ryegrass (Lolium perenne spp. multiflorum) Suppression Following Corn Harvest.

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Italian ryegrass (*Lolium perenne ssp. multiflorum*) is an emerging problem across North Carolina, where it causes substantial competition in winter wheat (*Triticum aestivum*). Management traditionally relies on burndown herbicide applications; however, resistance to paraquat and glyphosate has been confirmed in the state, along with resistance to the preemergence herbicides pyroxasulfone and flumioxazin. Interseeding summer cover crops into corn may provide an opportunity for cultural suppression of Italian ryegrass between summer crop harvest and winter wheat establishment, potentially reducing reliance on burndown herbicides and associated selection pressure. An on-farm study was established in Stokes County, North Carolina, during the summer of 2026 to evaluate the effects of cover crop species, seeding rate, and interseeding timing on cover crop establishment and subsequent Italian ryegrass suppression. The study was conducted in corn using a randomized complete block design. Three cover crop species were evaluated: sorghum-sudangrass at 45, 61, and 78 kg ha^{-1}; sorghum at 16, 34, and 50 kg ha^{-1}; and pearl millet at 16, 34, and 50 kg ha^{-1}. Cover crops were interseeded at three corn growth stages: V10, R2, and R5. Cover crop and Italian ryegrass density and biomass were measured following corn harvest in October. Cover crop species and interseeding timing interacted to influence cover crop density, whereas seeding rate had no significant effect. Sorghum-sudangrass interseeded at all three timings and sorghum interseeded at V10 established at significantly greater densities than the remaining treatments. No significant differences in Italian ryegrass densities were observed among treatments. Prolonged drought conditions across North Carolina during the growing season may have limited cover crop establishment and subsequent competitive ability. These results highlight the importance of cover crop species and interseeding timing when developing cultural weed management strategies for Italian ryegrass in winter wheat production systems.

79 - Alfalfa Reduces Herbicide Resistant Pigweed (*Amaranthus* spp.) Populations

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Herbicide resistance is a major obstacle in crop production, particularly weed species within the genus *Amaranthus (*e.g. waterhemp & Palmer amaranth). Alfalfa shows promise as a crop used in rotation to control resistant populations of these species. Research across multiple states has shown that established alfalfa can severely reduce the seed production of waterhemp. As the seed has a short longevity in the soil, we expect *Amaranthus* seedbanks to be severely reduced during alfalfa production however little is known about the impact of *Amaranthus* species in the establishment year of alfalfa. Experiments were established across three locations (Pennsylvania, Wisconsin, New Mexico) to evaluate the effectiveness of herbicides in controlling potentially resistant *Amaranthus* species in each state. Alfalfa was planted in spring of 2027 and an application of encapsulated acetochlor (after alfalfa emergence), 2,4-Db (2 leaf *Amaranthus* spp.) or 2,4-Db + pendimethalin (2 leaf *Amaranthus* spp.) was compared to a nontreated control. Alfalfa was harvested 2 (PA) or three (WI + NM) times and biomass of alfalfa and *Amaranthus* spp. were estimated at each harvest. Results were site specifics with 34-87% reductions in *Amaranthus* spp. biomass from herbicide treatments which resulted in 59-108% increase in alfalfa biomass in the first

harvest. *Amaranthus* spp. did not produce viable seed between cuts at any location. After the last cut (September) New Mexico had no surviving Palmer amaranth in any treatment, while waterhemp in Pennsylvania and Wisconsin persisted. While densities were high in Pennsylvania (19-140 plants m^{-2}) compared to Wisconsin (14-25 plants m^{-2}) plants were small (< 30 cm tall) with only a subset flowering or with fruit (50-83%). While herbicides limited *Amaranthus* spp. biomass at all sites, density was impacted at only one location (Pennsylvania). *Amaranthus* spp. seedbank and density estimates in 2027 and 2028 will quantify how much reduction in *Amaranthus* spp populations can be realized from three years of alfalfa production.

Student Poster Contest – Row Crop Herbicide Management

80 - Does Stacking Group 15 Herbicides with a Group 14 Herbicide Improve Early Season Residual Waterhemp Control in Soybean?

Joao Pedro Smaniotto[1], Daniel Smith[1], Ryan DeWerf[1], Nikola Arsenijevic[1], Ahmadreza Mobli[1], Rodrigo Werle[1]

[1]University of Wisconsin

Waterhemp (*Amaranthus tuberculatus*) is a major weed in Midwestern U.S. soybean production. Its prolonged emergence period, competitive ability, and prolific seed production potential contribute to substantial yield-loss risk and increase the challenges associated with herbicide resistance management. Soil residual herbicides have become essential components of soybean weed management programs because they suppress weed emergence and reduce early-season competition. Preemergence (PRE) herbicide programs containing multiple different sites of action can improve waterhemp control and help lower selection pressure on postemergence herbicides. Very-long-chain fatty acid (VLCFA)-inhibitor herbicides (Group 15) are commonly used in soybean PRE programs, but their effectiveness varies among products and weed populations. As Group 15 herbicide pyroxasulfone becomes more affordable, stakeholders are increasingly interested in either replacing their current Group 15 of choice, or combining two Group 15 herbicides (e.g., pyroxasulfone + S-metolachlor) with another herbicide from a different site of action group, such as a protoporphyrinogen oxidase (PPO)-inhibitor herbicide (Group 14). Research evaluating the effectiveness of these combinations is warranted. This study evaluated residual waterhemp control provided by combinations of Group 15 and 14 herbicides in soybean. A field experiment was conducted at O'Brien Family Farm near Brooklyn, Wisconsin in 2026. The randomized complete block design consisted of nine herbicide treatments, combining three Group 15 herbicide program options, S-metolachlor (1,605 g ai/ha), pyroxasulfone (128 g ai/ha), and S-metolachlor + pyroxasulfone (1,605 + 128 g ai/ha) with three Group 14 herbicides, saflufenacil (25 g ai/ha), fomesafen (263 g ai/ha), and sulfentrazone (210 g ai/ha), plus a nontreated control. The experiment included four replications, with plots measuring 3.1 × 9.1 m. Soybean variety P22A36PR was planted on May 21, 2026, followed by the PRE herbicide treatment applications on the same day. Waterhemp density was assessed 42 days after PRE herbicide application by counting plants in three 0.25-m^2 sampling squares within the center soybean rows of each plot. In general, treatments combining S-metolachlor + pyroxasulfone with a Group 14 herbicide resulted in higher waterhemp density reduction than treatments containing either

pyroxasulfone or S-metolachlor individually in combination with a Group 14 herbicide. Moreover, pyroxasulfone outperformed S-metolachlor containing treatments when a single Group 15 was used in combination with a Group 14 herbicide. The three-way combination (S-metolachlor + pyroxasulfone + Group 14) reduced waterhemp density compared with pyroxasulfone combined with saflufenacil and fomesafen, but not with sulfentrazone. Waterhemp control also varied among Group 14 herbicides when they were combined with S-metolachlor, with sulfentrazone as the most effective and saflufenacil as the least effective. Our preliminary 2026 results suggest that mixing pyroxasulfone and S-metolachlor with a Group 14 herbicide can improve waterhemp control. This project will be replicated across multiple locations in 2027. Further research across environments and weed populations is warranted to determine the consistency of these responses, to assess the effectiveness of these combinations against additional weed species, and to evaluate crop response.

81 - HiFlex™ Label Expansion Project for Storen®, Acuron® GT, Acuron® Flexi, and Acuron® Brands: Will Provide Increased Flexibility for Building Weed Control Programs

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[1]Syngenta Crop Protection

As weed control challenges continue to increase, corn growers need weed control programs that provide longer residual activity and increased rate flexibility across application timings. The proposed HiFlex™ rate label expansion aims to address these needs by increasing allowable rates and broadening program options for Storen®, Acuron® Flexi, Acuron® GT, and Acuron® corn herbicides. A key proposed change is an increase in the maximum annual rate of bicyclopyrone, up to 100 g ai/ha per year across the four brands. The amendments would also increase the maximum single-application rates of Storen® (from 2.4 to 3.1 qt/A), Acuron® Flexi (from 2.25 to 3.0 qt/A), and Acuron® GT (from 3.75 to 4.5 pt/A) corn herbicides. These higher rates are designed to give growers options for greater active ingredient delivery and more rate flexibility in both pre- and post-emergence applications. Federal label amendments are pending approval by the U.S. Environmental Protection Agency, with the potential of becoming available for use in the 2027 growing season. Until approved, all existing product labels and use directions remain in effect.

82 - Efficacy of Mesotrione-Based PRE Programs for Early Season Residual Waterhemp Control in Vyconic™ Soybean

Alice Lazzari[1], Ryan DeWerff[1], Sabeel Abuhakmeh[1], Rodrigo Werle[1]

[1] University of Wisconsin-Madison

Vyconic™ technology will allow for preemergence (PRE) applications of mesotrione in soybean, pending regulatory approvals. Reliance on mesotrione alone may provide inconsistent waterhemp (*Amaranthus tuberculatus*) control and increase selection pressure for resistance to 4-hydroxyphenylpyruvate

dioxygenase (HPPD)-inhibiting herbicides. Integrating mesotrione with other residual herbicides and sites of action will be needed to ensure effective stewardship of the technology. Therefore, understanding the value of mesotrione within diversified PRE herbicide programs will aid in the development of effective and sustainable recommendations for this new soybean technology. The objectives of this research were to quantify the contribution of mesotrione to residual waterhemp control in PRE herbicide programs and to identify tank mixtures that provide effective and consistent residual waterhemp control. A bareground field experiment was conducted in 2026 with two experimental runs at the Lancaster Agricultural Research Station (LARS, silt loam soil), and two experimental runs in Brooklyn (sandy loam soil; confirmed waterhemp resistance to HPPD-inhibitor herbicide mesotrione), WI. The experiment was conducted as a randomized complete block design with four replications and 15 treatments. Treatments consisted of a nontreated control, acetochlor (1,261 g ai ha^{-1}), flumioxazin (70 g ai ha^{-1}), metribuzin (315 g ai ha^{-1}), and mesotrione (126 g ai ha^{-1}) applied alone and in all possible two- and three-way combinations. Herbicides were applied using TTI 110015 nozzles delivering 140 L ha^{-1}. Waterhemp control from 0 to 100% was visually assessed at 21, 28, 35, 42, 49, and 56 days after treatment (DAT); data collected 42 DAT will be discussed herein. At LARS, individual herbicides provided 52 to 68% control, two-way mixtures provided 73 to 89% control, and three-way mixtures provided 93 to 95% control. At Brooklyn, where overall control was lower, likely due in part to confirmed mesotrione resistance and potentially greater herbicide dissipation in the lighter-textured soil, individual herbicides provided 4 to 49% control, and no treatment provided ≥90% control. For instance, mesotrione alone provided 54% control 42 DAT at LARS and 4% at Brooklyn. The most effective two-way mixture at both locations was acetochlor + flumioxazin providing 84 and 80% waterhemp control at LARS and Brooklyn at 42 DAT, respectively. The most effective programs at Brooklyn were acetochlor + flumioxazin + metribuzin and acetochlor + flumioxazin + mesotrione, providing 83 and 82% waterhemp control at 42 DAT, respectively. These preliminary results support the importance of integrating mesotrione with multiple effective residual herbicide sites of action, particularly in field with HPPD-inhibitor metabolically resistant populations and light soil texture. The three-way mixtures tested provided greater and more consistent residual waterhemp control at the mesotrione-susceptible location (LARS) than individual herbicides and two-way mixtures. However, at the mesotrione-resistant location (Brooklyn), mesotrione did not provide effective residual waterhemp control. Diversified PRE herbicide programs will be needed to maximize the value and ensure the long-term utility of mesotrione in Vyconic™ soybean systems.

83 - Evaluating Two-Way Tank Mixes for Postemergence Control of Herbicide-Resistant Waterhemp (Amaranthus tuberculatus) in Corn

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The proliferation of herbicide resistance in waterhemp (*Amaranthus tuberculatus* Moq.), including populations resistant to multiple sites of action, combined with new developments in herbicide resistance technology in crops, particularly soybean (*Glycine max* L.) and corn/maize (*Zea mays* L.), has altered the

chemical weed control landscape in Wisconsin and beyond. The combination of multiple herbicides in one postemergence (POST) application can increase weed control and potentially delay development of herbicide resistance, but new developments warrant the need to evaluate the efficacy of potential POST tank-mixture options. The objective of this study was to investigate whether two-way active ingredient combinations are consistently more effective than single active ingredient solutions and to evaluate which herbicide programs may provide effective (>85% mortality and biomass reduction) POST control of herbicide-resistant waterhemp in maize. A greenhouse experiment was conducted following a factorial design of one hundred and five herbicide treatments and three Wisconsin waterhemp accessions (i.e., 105x3). Herbicide treatments included fourteen different active ingredients across seven sites of action (Group 4: 2,4-D, dicamba, and clopyralid; Group 5: atrazine; Group 6: bentazon, bromoxynil, and pyridate; Group 9: glyphosate; Group 10: glufosinate; Group 14: fluthiacet-methyl; and Group 27: mesotrione, topremazone, tolpyralate, and tembotrione) applied at label rates and all possible two-way active ingredient mixtures. Treatments were applied using distilled water as the carrier without the addition of adjuvants. Waterhemp accessions studied included A106, A125, and A133, collected from locations across Wisconsin and chosen due to their varying herbicide resistance profiles. Treatments were applied when average waterhemp plant height was 10 cm using a research spray chamber calibrated to deliver 140 L ha-1 with an AI09502 nozzle. Twenty-one days after treatment (DAT), mortality data were recorded and plants were harvested then dried to constant weight to obtain biomass. Mortality and biomass reduction 21 DAT were estimated with populations treated as random to determine treatment efficacy across a variety of waterhemp herbicide resistance profiles. Eighteen out of 105 treatments provided effective control of waterhemp (≥85% mortality and biomass reduction). Out of eighteen treatments with effective control, all were two-way active ingredient mixes, with eleven treatments containing either glufosinate or 2,4-D. The remaining seven effective treatments were composed of mixes between Group 5/6 (pyridate, bromoxynil, atrazine) and Group 27 (mesotrione, tolpyralate, tembotrione) herbicides. Excluding glufosinate and 2,4-D, no single active ingredient treatment achieved ≥85% biomass reduction nor ≥30% mortality, with respective ranges of 17-84% biomass reduction and 0-29% mortality, showing a lack of consistent efficacy from most single active ingredient treatments to control herbicide-resistant waterhemp. Our results are emblematic of the importance of assessing weed mortality in addition to biomass reduction for herbicide resistance research and are indicative of promising two-way mixtures that are capable of providing more effective control of multiple herbicide-resistant waterhemp. However, future research is needed to assess treatment performance in the field and evaluate mixture compatibility and phytotoxicity in current and future maize cropping systems.

84 - Tiafenacil (Reviton) Based Herbicide Programs for Terminating Enlist Corn in Replant Situation

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Nebraska farmers grow more than 3.5 million ha of corn (*Zea mays* L.) annually, often faced with hail, frost, flooding, and strong winds which can reduce stands and create uneven plant populations. When replanting, the existing stand must be completely terminated, filling in gaps causes competition between the original and replanted stands as well as variability in grain moisture at harvest. Many farmers plant

corn resistant to 2,4-D, glufosinate, glyphosate, and quizalofop (Enlist® corn), which further limits herbicide options for termination. To evaluate tiafenacil-based herbicide programs for terminating Enlist corn in a replant situation, an irrigated field study was conducted at the University of Nebraska-Lincoln South Central Agricultural Laboratory near Clay Center, NE, in 2026. The experiment was a randomized complete block design with three replications and included a nontreated control. Corn hybrid P13777PCE (Pioneer, Johnston, IA) was planted on May 6, 2026, at 84,000 seeds ha^{-1}. A premixture of atrazine, bicyclopyrone, mesotrione, and *S*-metolachlor was applied PRE to the entire trial on May 8, 2026, at 2891 g ai ha^{-1}. Treatments were applied at the V2 to V3 corn stage and included tiafenacil at 25 or 50 g ai ha^{-1} mixed with clethodim (35 g ai ha^{-1}), tiafenacil at 37 g ai ha^{-1} mixed with paraquat (841 g ai ha^{-1}), tiafenacil at 50 g ai ha^{-1} mixed with atrazine (560 g ai ha^{-1}), and a premixture of tiafenacil and glufosinate (23 + 786 g ai ha^{-1}) mixed with clethodim (35 g ai ha^{-1}). Clethodim was included because Enlist corn is not resistant to cyclohexanedione herbicides. All treatments included methylated seed oil at 1% v/v and were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 140 L ha^{-1}. Corn control was visually rated (0% to 100%) at 14 and 28 days after treatment (DAT). Data were subjected to ANOVA using PROC GLIMMIX in SAS 9.4 with block as a random effect, and means were separated using Tukey’s HSD test ($P \leq 0.05$). At 14 DAT, the tiafenacil and glufosinate premixture combined with clethodim controlled corn 95%, similar to tiafenacil at 50 g ai ha^{-1} mixed with clethodim (91%). Tiafenacil at 25 g ai ha^{-1} mixed with clethodim and tiafenacil mixed with paraquat controlled corn 83% and 82%, respectively. At 28 DAT, the tiafenacil and glufosinate premixture combined with clethodim provided the greatest control (90%), whereas tiafenacil mixed with clethodim (75% to 81%) or paraquat (80%) did not differ. Tiafenacil mixed with atrazine controlled corn ≤7% at both evaluations. Only the tiafenacil and glufosinate premixture mixed with clethodim provided ≥90% control of Enlist corn at 28 DAT. Tiafenacil mixed with clethodim or paraquat provided 75% to 81% control, which may leave surviving plants that compete with the replanted stand, and tiafenacil mixed with atrazine was not effective.

85 - Burcucumber (*Sicyos angulatus*): Control Recommendations in Corn and Soybean

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Beginning in the late 1990s until now, researchers at Penn State University have conducted various experiments on burcucumber (*Sicyos angulatus*) biology and management. From these studies and through years of experience, certain herbicide options and tactics can be recommended to farmers to help manage this problem weed in agronomic crops.

Why is burcucumber so difficult to manage?

- Prolonged seedling emergence from late April through mid-August
- Burcucumber seeds can germinate from 6 inches below the soil surface or easily emerge through a thick cover crop residue
- Preplant tillage can encourage multiple flushes of burcucumber throughout the growing season
- Crop row spacing alone is not effective at suppressing burcucumber

· Vines of some mature plants can be over 20 feet long and can span more than six corn rows entangling with the crop and other vines

· Aggressive growth habit can significantly reduce crop yield and make harvesting of either grain or forage nearly impossible

· Mature (dark brown) seeds have a hard coat which is unaffected by the ensiling process

· Prolonged seed dormancy, thus a lasting seed reservoir in the soil and the potential for a burcucumber problem for many years

Herbicide recommendations for burcucumber control

· Because burcucumber can emerge throughout the growing season, one-pass PRE herbicide programs will not be adequate; as well as herbicide programs that lack residual activity.

· Good control of burcucumber in both corn and soybean, requires - at a minimum - a two-pass herbicide program composed of an effective PRE application followed by a POST treatment that includes a residual for season-long control.

· In field corn—products containing mesotrione, isoxaflutole, and atrazine are the primary herbicides that provide residual control at planting. Glyphosate and/or dicamba will likely be used POST but must have a residual like prosulfuron and/or mesotrione in the mix for late season residual. (Prosulfuron provided the most consistent control in Penn State field trials.)

· In corn, later herbicide applications (approximately 20- to 25-inch-tall corn) provide better late season control of burcucumber than POST applications made at the 12-inch corn stage.

· In soybean—products containing chlorimuron, metribuzin, glyphosate, and dicamba (XtendFlex platforms) are the main herbicides used in control programs. Furthermore, chlorimuron should be applied in both the PRE and POST applications for optimal residual control during the growing season.

· Maximum crop stage spray application cutoffs must be considered. For example, spraying glyphosate in glyphosate-tolerant corn during the tasseling stage or soybean at the R5 stage would be off-label applications. Therefore, follow all product label guidelines when making later-season applications with high-boy sprayers, drones, etc. And preharvest burcucumber control is usually not effective.

Other management considerations

· No-till practices keep the seeds on the soil surface, thus allowing germination to occur over a shorter period and reducing the number of germination flushes (this also improves herbicide effectiveness and performance)

· Shorter season corn varieties allow earlier silage harvest (ensiling kills green/immature burcucumber seed)

For additional information, please refer to an article at the GROW website: https://growiwm.org/weeds/burcucumber/ .

86 - Palmer amaranth (*Amaranthus palmeri*) Control with Burndown or Residual Herbicides in Double-Crop Scenarios

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[1]Kansas State University, [2]Syngenta

Palmer amaranth (*Amaranthus palmeri* S. Watson) is a highly competitive weed that can pose challenges in wheat stubble and double-crop production systems. There is a need to understand burndown herbicide alternatives to the current market standard of paraquat. Two separate field trials were conducted in south-central Kansas in 2026 to evaluate herbicide strategies for Palmer amaranth management. The first trial evaluated paraquat-free burndown programs for Palmer amaranth control in wheat stubble before planting soybean. Four herbicide treatments programs were evaluated using two application timings (A on June 23 followed by B on June 30): glufosinate plus 2,4-D choline followed by glufosinate, glufosinate plus 2,4-D choline at both timings, saflufenacil followed by glufosinate, and saflufenacil followed by glufosinate plus 2,4-D choline. The second trial evaluated seven soil-applied residual herbicide treatments applied to wheat stubble on June 23. Treatments included a nontreated residual check, pyroxasulfone, flumioxazin, combinations of pyroxasulfone plusand flumioxazin, metribuzin plusand flumioxazin, pyroxasulfone plus, flumioxazin plus, and metribuzin, and metribuzin plus S-metolachlor. Both trials had treatments arranged in an RCBD with three replications. All treatments were applied with a CO2-pressurized backpack sprayer with appropriate adjuvants included. Visual Palmer amaranth control was evaluated 7 days after second timing in first trial, and at as percent control 21 days after application in second trial (DAA). In the first trial, glufosinate- and 2,4-D choline-based treatments provided better visual Palmer amaranth control than saflufenacil-based treatments. Saflufenacil-based programs with glufosinate at timing B provided less control than both glufosinate plus 2,4-D based programs, including when followed by a subsequent application of glufosinate plus 2,4-D choline. Differences between these programs were significant. In the second trial, increasing the number of residual herbicide sites of action resulted in significant improvements in visual Palmer amaranth control. Three sites of action resulted in 87% control as compared to all other treatments that resulted in 72% or less by 21 days after application. These findings suggest that paraquat-free burndown programs containing glufosinate and 2,4-D choline may provide improved Palmer amaranth control compared to saflufenacil-based programs. Additionally, incorporating multiple residual herbicide sites of action improved Palmer amaranth control in double-crop production systems. Diversifying herbicide programs across burndown and residual applications may provide an effective approach to managing Palmer amaranth in south-central Kansas.

87 - Day vs. Night: Comparing the Effect of Herbicide Application Timing on Weed Control

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In recent years, agrorobotics have become a viable technology that can be potentially utilized in corn and soybean weed management systems. Many of these machines are designed to operate autonomously throughout the day and night to maximize efficiency. Although these machines may be capable of making herbicide applications throughout the night, little research has been conducted comparing the efficacy of daytime versus nighttime herbicide applications. A field experiment was conducted in 2026 to compare the effectiveness of several commonly used corn and soybean herbicides when applied during the day versus night. Each active ingredient was applied at the same rate at 1:00 PM and 1:00 AM to waterhemp

(*Amaranthus tuberculatus*) ranging from 10 to 18 cm in height. Visual weed control ratings were taken at 3, 7, 14, and 28 days after application (DAA), and waterhemp biomass was determined at 28 DAA. At 28 DAA, daytime applications of topramezone, 2,4-D, mesotrione, and glufosinate resulted in significantly greater waterhemp control (54 to 94%) than nighttime applications (10 to 46%). These differences were also reflected in the waterhemp biomass data, as daytime applications of topramezone, 2,4-D, mesotrione, and glufosinate at the full rate resulted in 54 to 79% less biomass, respectively, compared to nighttime applications. In contrast, application timing did not significantly influence waterhemp control or biomass following applications of atrazine, fomesafen, paraquat, flumiclorac, imazethapyr, clethodim, or dicamba. These results suggest that herbicide selection may be an important consideration for autonomous spraying systems that operate at night, as the effectiveness of certain herbicides may be substantially reduced compared to daytime applications.

88 - Two-Way Herbicide Tank-Mix Interactions for Control of Key Broadleaf Weeds

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Herbicide tank mixtures may broaden the spectrum of targeted weed species, improve broadleaf weed control, and increase application efficiency in corn and soybean production systems. However, the justification for joint application depends on the effectiveness of selected combinations and how the components interact compared with individual applications. This study aimed to test the efficacy of the tank mix against targeted broadleaf weeds and to determine the nature of the tank mix's efficacy and the interactions between active ingredients. The study includes five active ingredients dicamba (280 g ae ha^{-1}), 2,4-D (532 g ae ha^{-1}), glufosinate-P-ammonium (185 g ai ha^{-1}), glyphosate (630 g ae ha^{-1}), and mesotrione (52.5 g ai ha^{-1}), individually and in two-way tank mixtures on *Amaranthus palmeri* S. Watson, and *Chenopodium album* L. Plants from 10 to 15 cm tall were treated using a PSLDMQ2004 nozzle calibrated to deliver 140 L ha^{-1} at 276 kPa and 3.53 m s^{-1}. Visual control was assessed at 21 days after application (DAA). Aboveground biomass was harvested at 21 DAA, dried at 55˚C until constant weight was achieved, and weighed to determine dry biomass. Most mixtures were highly effective against *A. palmeri* at 21 DAA: nine caused 96 to 100% visual control and 97 to 99% dry biomass reduction. The only exception was that glyphosate + mesotrione caused only 20% visual control and 66% biomass reduction. On *C. album*, mixtures overall caused 89 to 100% control and 96 to 99% biomass reduction. Four mixtures were synergistic for visual control but antagonistic for biomass reduction. Notably, 2,4-D + mesotrione caused 99% control versus 86% expected ($p < 0.0015$), whereas dicamba + glyphosate reduced biomass by 96% versus 100% expected ($p < 0.001$). Glufosinate-P-ammonium mixtures with glyphosate or mesotrione caused 100% of the control and at least 98% biomass reduction in both species. Overall mixture performance was influenced by weed species. Glufosinate-P-ammonium mixtures with glyphosate or mesotrione were highly effective against both species under the tested conditions. However, high efficacy did not exclude antagonism, highlighting the need to interpret interaction classifications alongside observed responses. When both components alone provided near-complete control, antagonism

reflected differences of only a few percentage points between observed and expected responses, which were statistically detectable but agronomically negligible.

89 - Effect of Sequential Application Timing of Glufosinate Following 2,4-D on Weed Control

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Sequential herbicide applications are essential components of effective weed management programs, particularly when managing diverse weed populations and extended emergence periods. However, the interval between applications is an important consideration that may influence weed control outcomes. The present study evaluates the performance of 2,4-D choline application followed by glufosinate applications at different timings under soybean (*Glycine max* (L.) Merr.) field conditions. 2,4-D choline (1065 g a.e. ha^{-1}) and L-glufosinate-ammonium (Glu-L, 370 g ai ha^{-1}) were applied with dry ammonium sulfate (2,241.7 g ha^{-1}) and a drift reduction agent (0.3% v v^{-1}). Both active ingredients were evaluated individually, as a tank mixture, and sequentially. The initial application of 2,4-D choline was followed by glufosinate applications at 0 and 4 hours after application (HAGA) and 1, 3, and 6 days after application (DAGA). Applications were made with a CO_2 backpack sprayer calibrated to deliver 140 L ha^{-1} at 276 kPa with MR11002 nozzles with 50.8 cm spacing and boom height. Weed species reached 10 to 15 cm and were present at the time of application common lambsquarters (*Chenopodium album* L.), Palmer amaranth (*Amaranthus palmeri* S. Watson), and bristly foxtail (*Setaria verticillata* (L.) P. Beauv.), which were present in plots and, due to low performance on 2,4-D, showed no response. Visual control was assessed at 4, 8, 12, and 24 days after the corresponding treatment application (DAA), with biomass collected from a 1-m^2 area for each weed species at 24 DAA. No differences in weed control were observed between tank-mixed and dual-boom applications of 2,4-D choline and glufosinate. At 4 DAA, the sequential treatment with glufosinate applied 3 DAGA resulted in 95% visual control of common lambsquarters. Similarly, glufosinate applied 6 DAGA resulted in 99% visual control of Palmer amaranth at 8 DAA. In contrast, 2,4-D choline alone provided lower visual control across weed species, including 40% for common lambsquarters and 41% for Palmer amaranth. Across sequential treatments, visual control of common lambsquarters and Palmer amaranth ranged from 60% to more than 70% at 4 and 8 DAA, with some delayed application timings providing greater control. By 12 DAA, delayed sequential applications did not compromise weed control, suggesting flexibility in application timing and opportunities to target additional weed species or subsequent weed emergence, although additional applications may increase operational costs. However, additional applications may increase the environmental footprint and application costs, highlighting the need to balance weed management benefits with operational efficiency.

90 - Multiple applications of selected Group 15 herbicides do not adversely affect soybean

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Very-long-chain fatty acid-inhibiting herbicides (Group 15) are applied extensively to manage weeds preemergence. Group 15 herbicides are being applied post residual to reduce the amount of later germinating weeds. Minimal data is present to determine the influence of multiple applications of these herbicides on soybean injury, height and yield. Field studies were conducted to determine the effect of multiple applications of Group 15 herbicides on soybean yield. Experiments were conducted in Delaware (2025), Iowa (2025), North Carolina (Kinston and Rocky Mount [2024]), Pennsylvania (2025) and South Dakota (South Shore and Volga [2024 and 2025]), respectively. *S*-metolachlor (1703 g ai ha^{-1}) and encapsulated acetochlor (1261 g ai ha^{-1}) were applied at three different timings: preemergence, early postemergence (V2-V3), and mid postemergence (V5-V6). All timings were applied in a factorial arrangement. These two herbicides were selected based on immediate plant availability (*S*-metolachlor) and delay availability (encapsulated acetochlor). Glufosinate (655 g ai ha^{-1}) and glyphosate (1260 g ae ha^{-1}) were applied between the early and mid postemergence application to manage weeds that could confound putative yield loss. Experiment location was considered random to increase the inference of the data. Application timing influenced soybean injury, where injury ranged from 0 to 6%. Similarly, application timing resulted in differential soybean height where the greatest differences were 6 cm. Neither herbicide influenced either variable. Soybean yield was not different across all tested treatments. The results of this experiment suggest that multiple applications of Group 15 herbicides do not affect soybean yield. However, minimal injury and height differences may occur.

91 - Influence of Application Timing for Dicamba and Glufosinate Applied Alone or in Mixture for Waterhemp (*Amaranthus tuberculatus*) Management

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XtendFlex soybean is tolerant to dicamba, glyphosate, and glufosinate, allowing postemergence applications of these herbicides individually or in combination. Recent labeling now allows for dicamba and glufosinate to be applied in mixture with the use of a non-ammonium sulfate water conditioner. Limited data is available on the efficacy of this mixture applied to manage waterhemp in soybean. The objective of this study is to evaluate the effects of the herbicide (dicamba [560 g ae ha^{-1}] or glufosinate [409 g aie ha^{-1}]) applied alone or in combination and application timing (V4 or R1) on waterhemp control, seed production, and soybean yield. Field experiments were conducted in Volga and Beresford, SD, during the summer of 2026. All herbicide treatments provided similar waterhemp control at both

locations, on average. Application timing influenced waterhemp control at both locations, where V4 applications provided 15% greater control than R1 applications. While differences in control between herbicides at each application timing were observed at Volga, each herbicide treatment provided greater control when applied at V4. Waterhemp seed production at Beresford was highly variable due to minimal surviving female plants observed with tested treatments. Waterhemp seed production differed by application timing, where 741 and 2077 seeds female^{-1} were observed at the V4 and R1 timings, respectively. Soybean yield was greatest with dicamba + glufosinate applied at both timings and dicamba (V4), while yield was lowest with dicamba (R1) at Beresford. Glufosinate applied at either timing resulted in intermediate soybean yields. Conversely, soybean yield was greater with glufosinate (V4), followed by dicamba + glufosinate (V4) and glufosinate (R1) at Volga. Soybean yield was the lowest with dicamba (V4), and intermediate yields were observed with dicamba + glufosinate (R1) and dicamba (R1). The results of this experiment provide evidence that waterhemp control is similar with all tested herbicide treatments, but greater control is realized with V4 application timing. The effectiveness of these herbicides applied at the V4 timing was further demonstrated with reductions in seed production at both locations. While soybean yields were variable with herbicides and application timing, yields were generally greater with dicamba + glufosinate applied at either timing at both locations. Therefore, dicamba + glufosinate with a non-ammonium water conditioner applied at V4 can be an effective component of a weed management plan in soybean.

92 - Can PPO Herbicides Enhance Glufosinate Efficacy For Amaranthus Control?

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Palmer amaranth (*Amaranthus palmeri* S. Watson) is a difficult weed to manage in row crop production. Glufosinate provides postemergence control, but its performance may vary with environmental conditions and plant size. This study evaluated whether adding protoporphyrinogen oxidase (PPO)-inhibiting herbicides to glufosinate improves Palmer amaranth control and maintains efficacy over time. A field experiment was conducted in 2026 at Ashland Bottoms Research Farm near Manhattan, Kansas, using a randomized complete block design with four replications. All nine treatments contained glufosinate-ammonium at 0.594 kg ai ha^{-1} and ammonium sulfate at 3.36 kg ha^{-1}. Glufosinate was applied alone or with one of eight PPO herbicide treatments: fomesafen (0.2634 kg ai ha^{-1}), lactofen (0.1751 kg ai ha^{-1}), carfentrazone-ethyl (0.0140 kg ai ha^{-1}), epyrifenacil (0.0201 kg ai ha^{-1}), flumioxazin (0.1072 kg ai ha^{-1}), saflufenacil (0.0499 kg ai ha^{-1}), tiafenacil (0.0743 kg ai ha^{-1}), or saflufenacil + trifludimoxazin (0.0365 + 0.0183 kg ai ha^{-1}). Adjuvants were added according to each treatment, including methylated seed oil, crop oil concentrate, or nonionic surfactant. Herbicides were applied when Palmer amaranth plants were approximately 10 to 15 cm tall, using 140 L ha^{-1}spray volume. Visual control was assessed at 7, 14, 21, and 28 days after treatment (DAT), using a scale from 0% (no control) to 100% (complete control). Visual control at each assessment was analyzed by analysis of variance (ANOVA), followed by Tukey's Honestly Significant Difference (HSD) test for treatment comparisons. At 7 DAT, glufosinate alone provided 65% control, whereas mixtures with lactofen, epyrifenacil, flumioxazin, saflufenacil, tiafenacil, and

saflufenacil + trifludimoxazin provided 86 to 97% control. Weed control by these six mixtures was similar[SG1] and greate[SG2] r than glufosinate alone. The same mixtures remained superior at 14 DAT, providing 79 to 94% control compared with 54% for glufosinate alone. At 21 DAT, five mixtures, lactofen, epyrifenacil, flumioxazin, tiafenacil, and saflufenacil + trifludimoxazin, provided similar control of 76 to 93%, exceeding the 40% control from glufosinate alone. At 28 DAT, glufosinate alone provided 30% control. Mixtures with saflufenacil + trifludimoxazin, epyrifenacil, flumioxazin, and lactofen provided greater control of 63, 63, 78, and 74%, respectively. The four better-performing mixtures were statistically similar at 28 DAT, despite differences in their numerical control values. Fomesafen and carfentrazone-ethyl did not improve control over glufosinate alone at any assessment. To evaluate consistency over time, the reduction in control from 7 to 28 DAT was calculated for each plot and analyzed with a linear mixed model, with treatment as a fixed effect and block as a random effect. Control declined by 35 percentage points with glufosinate alone, compared with numerical declines of 19 and 20 points for mixtures with flumioxazin and lactofen, but neither mixture differed from glufosinate alone. Greater control at an individual assessment did not necessarily indicate a significantly smaller decline in control over time. Overall, selected PPO mixtures improved Palmer amaranth control, but effects differed among herbicides. Further studies across locations, environmental conditions, and weed sizes could identify combinations that provide more reliable control.

93 - Evaluation of Potential Herbicide Programs for Vyconic™ Soybeans: Crop Injury and Weed Control.

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Herbicide-resistant weeds have increased the complexity of weed management in soybean production, emphasizing the need for herbicide programs that incorporate multiple sites of action. Vyconic™ soybean is a technology under development with tolerance to glyphosate, glufosinate, dicamba, 2,4-D, and mesotrione, pending regulatory approvals, providing additional flexibility for weed management. The objective of this study was to evaluate Palmer amaranth (*Amaranthus palmeri* S. Watson) and morningglory (*Ipomoea purpurea* (L.) Roth) control and soybean injury following different preemergence (PRE) and postemergence (POST) herbicide programs in Vyconic™ soybean, determine crop response and recovery over time, and assess consistency across evaluation timings. A field experiment was conducted at Ashland Bottoms Research Farm near Manhattan, Kansas, using a randomized complete block design (RCBD) with four replications and 15 treatments, including a nontreated control. Herbicide programs included different combinations of acetochlor, mesotrione, metribuzin, dicamba, glyphosate, glufosinate, and 2,4-D. Crop injury and weed control following PRE applications were evaluated at 14, 21, and 28 days after application (DAPR). POST applications were made when soybean was at the V3 growth stage and weeds were approximately 4 inches tall. Crop injury and weed control following POST applications were evaluated 7, 14, 21, and 28 days after POST application (DAPO). Data were analyzed using analysis of variance (ANOVA), with herbicide treatments as a fixed effect and replication as a random effect. Soybean injury following PRE applications was numerically greatest (approximately 33%)

following acetochlor + mesotrione and metribuzin at 14 DAPR. Injury declined to approximately 17% at 21 DAPR and was absent at 28 DAPR. Soybean injury at 7 and 14 DAPO was primarily characterized by chlorosis and necrosis. Injury was numerically greatest (40%) at 7 DAPO for treatments 9, 12, and 15, and was no longer observed at 28 DAPO. Palmer amaranth control following PRE applications remained consistently high across all evaluation timings, ranging from 94 to 99%. Morningglory control following PRE applications ranged from 65 to 99% at earlier evaluations and from 84 to 99% at 28 DAPR. Treatments 2, 14, and 15 resulted in numerically greater morningglory control (approximately 99%) than other treatments at 28 DAPR. Following POST applications, morningglory control ranged from 92 to 99% through 28 DAPO, whereas Palmer amaranth control varied from 38 to 99%. Treatments 7-10 and 12-15 consistently provided approximately 98 to 99% Palmer amaranth control, while treatments 5, 6, and 11 showed less control. Overall, the evaluated herbicide programs provided effective weed control while allowing Vyconic™ soybean to recover from temporary crop injury. Pending regulatory approvals, the flexibility to integrate multiple herbicide sites of action in PRE- and POST-emergence programs may broaden weed management options, improve control consistency, and support resistance-management strategies.

94 - Evaluating Herbicide Programs for Waterhemp (*Amaranthus tuberculatus*) Control

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Waterhemp (*Amaranthus tuberculatus*) is one of the most troublesome weeds in the U.S. Midwest corn-soybean production systems. The widespread occurrence of multiple herbicide resistance in waterhemp populations further complicates its management. Three separate bare-ground field experiments were conducted near Iroquois, South Dakota, in 2026 to evaluate available PRE-only, POST-only, and PRE followed by (fb) POST herbicide programs for waterhemp control. Nine PRE-only treatments across Groups 3, 5, 14, 15, and 27, nine POST-only treatments across Groups 2, 4, 5, 9, 10, 14, and 27, and ten PRE fb POST herbicide programs were evaluated. All experiments were conducted in a randomized complete block design with four replications. Visual estimates of waterhemp control were recorded at 7, 14, and 28 days after the last herbicide application. Data were analyzed in SAS using the PROC GLIMMIX procedure. Waterhemp control did not differ among PRE-only treatments at 28 days after treatment (DAT) and ranged from 65% to 84%. Among POST-only treatments, the greatest waterhemp control at 28 DAT was observed with dicamba at 561 g ha^{-1} (83%) and glufosinate at 447 g ha^{-1} (74%), followed by 2,4-D choline at 1,065 g ha^{-1} (56%). The least control was observed with atrazine at 1,121 g ha^{-1} (3%) and imazamox at 53 g ha^{-1} (4%). For PRE fb POST herbicide programs, waterhemp control at 28 days after the POST application ranged from 43% to 100%. Flumioxazin/pyroxasulfone/metribuzin (370 g ha^{-1}) fb acetochlor + dicamba (1,261 + 561 g ha^{-1}) (100%), flumioxazin/pyroxasulfone/metribuzin fb glufosinate + 2,4-D choline (447 + 1,065 g ha^{-1}) (99%), S-metolachlor/metribuzin (1,822 g ha^{-1}) fb glufosinate + 2,4-D choline (96%), and saflufenacil/dimethenamid-P (228 g ha^{-1}) fb pyroxasulfone (179 g ha^{-1}) + glufosinate + 2,4-D choline (94%) provided the greatest control. S-metolachlor/fomesafen (1,483 g ha^{-1}) fb glufosinate + 2,4-D choline, S-metolachlor/atrazine/mesotrione/bicyclopyrone (1,928 g ha^{-1}) fb dicamba, sulfentrazone/pyroxasulfone (291 g ha^{-1}) fb lactofen (210 g ha^{-1}) + dicamba, and

acetochlor/atrazine (3,363 g ha^{-1}) fb pyridate + mesotrione (350 + 105 g ha^{-1}) provided 75% to 86% control. These results highlight the importance of using effective PRE fb POST herbicide programs containing multiple sites of action rather than relying on a single site of action for waterhemp management.

95 - Residual Herbicides in Wheat to Reduce Amaranthus Pressure Prior to Interseeded or Double-Crop Soybean

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Winter wheat-soybean interseeding can extend the soybean growing season but presents challenges for residual herbicide selection, crop safety, and weed management. A field experiment was conducted during the 2025-2026 growing season near Manhattan, Kansas, to evaluate residual herbicide performance across application timings and cropping systems. Ten herbicide treatments included pyroxasulfone, metribuzin, pendimethalin, and chlorsulfuron applied in fall (12/22/2025) or spring (4/6/2026), spring-applied MCPA, and a nontreated control. Winter wheat was seeded in 19-cm rows, either continuously or with every fourth row skipped. Interseeded soybean was planted into standing wheat on 4/22/2026, in 76-cm row gaps, while double-crop soybean was planted following wheat harvest on 7/10/2026. Treatments were arranged in a split-plot randomized complete block design with four replications, with herbicide treatment as whole plots and cropping system as subplots. Weed density and biomass, wheat and soybean herbicide injury (on a 0 to 100% scale, where 0% is no injury), soybean stand density, and wheat grain yield were evaluated. Standard errors (SE) are reported with means. Interseeded soybean had fewer Palmer amaranth plants (23 ± 1.3 plants m^{-2}) than double-crop soybean (27 ± 1.2 plants m^{-2}) on 6/29/2026, one day after wheat harvest. Fall- and spring-applied pyroxasulfone and spring-applied pendimethalin reduced Palmer amaranth biomass to 6.8 ± 2.03, 6.4 ± 2.03, and 6.4 ± 2.03 g m^{-2}, respectively, compared with 18.8 ± 2.03 g m^{-2} in the nontreated control. Spring-applied pyroxasulfone or pendimethalin had the fewest Palmer amaranth plants (7.3 ± 1.4 plants m^{-2}) compared with the nontreated control (14.4 plants m^{-2}) on 8/2/2026, prior to postemergence cleanup. Palmer amaranth biomass differed by an interaction of herbicide treatment and cropping system. In interseeded soybean, spring-applied pyroxasulfone had the least Palmer amaranth biomass (24.8 ± 11.8 g m^{-2}) compared with the nontreated control (102.2 ± 11.8 g m^{-2}). Spring-applied herbicides generally provided better weed suppression than fall applications, and interseeded soybean generally had less Palmer amaranth biomass than double-crop soybean. Herbicide treatments did not affect wheat grain yield, which averaged 2.55 ± 0.15 Mg ha^{-1} in wheat before double-crop and 2.25 ± 0.15 Mg ha^{-1} in wheat with interseeded soybean. Little wheat injury from herbicide treatments was observed, with a maximum of 4% phytotoxicity following spring-applied metribuzin. Soybean injury was primarily associated with chlorsulfuron in the interseeded system, with spring-applied chlorsulfuron causing up to 7% visual injury. Interseeded soybean had fewer established plants (15.9 ± 0.8 plants m^{-2}) than double-crop soybean (22.8 ± 0.8 plants m^{-2}); however, interseeded soybean produced more aboveground biomass (603 ± 41 g m^{-2}) than double-crop soybean (376 ± 41 g m^{-2}) by 9/22/2026. Herbicide treatments did not affect soybean height or biomass. Overall, spring-applied residual herbicides provided better Palmer amaranth suppression than fall applications, especially when used in interseeded soybean. Spring-applied pyroxasulfone and pendimethalin were among the most effective treatments.

Most residual herbicides were safe for both wheat and soybean, excluding chlorsulfuron and metribuzin, which were known to have possible crop injury. Skipping every fourth wheat row did not result in more Palmer amaranth plants or biomass, especially as interseeded soybean provided additional crop competition as compared to later-planted double-crop soybean.

96 - Linking Weed Control and Species Composition to Yield and Nutritive Value in Newly Seeded Alfalfa

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Alfalfa (*Medicago sativa* L.) is an important perennial forage crop in Kansas, valued for its high yield and nutritive value in livestock production. Weed interference during establishment can affect forage production and quality, highlighting the importance of effective weed management. However, evaluating weed management strategies requires considering both forage dry matter yield and nutritive value. Our objectives were to (1) quantify how herbicide programs affect weed species composition, forage yield, and nutritive value in newly seeded alfalfa, and (2) estimate the relationship between weed proportion in the forage and nutritive value. A field study was conducted in Agronomy North Farm, Manhattan, KS, in 2026 as a randomized complete block design with four replications and ten treatments: a nontreated control; S-Ethyl dipropylthiocarbamate (EPTC, 2,940 g ha^{-1}) preplant incorporated; acetochlor (1,260 g ha^{-1}) early postemergence; imazamox (44 g ha^{-1}) and bromoxynil (420 g ha^{-1}) postemergence, alone or tank-mixed; and EPTC or acetochlor followed by imazamox or imazamox + bromoxynil. At each of two harvests, conducted 7 and 15 weeks after treatment (WAT), 1 m² per plot was clipped and hand-separated into alfalfa, yellow foxtail (*Setaria pumila* (Poir.) Roem. & Schult.), and Venice mallow (*Hibiscus trionum* L.). Harvested subsamples were collected for nutritional analysis. Crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and relative feed value (RFV) were determined by wet chemistry analysis. Weed biomass and species composition were analyzed with generalized linear mixed models, and forage yield and nutritive value with linear mixed models. Herbicide program significantly affected weed biomass and species composition. At first harvest, bromoxynil alone reduced Venice mallow (8% of forage vs. 28% in the nontreated control) but left yellow foxtail the dominant weed (55% of forage), whereas imazamox alone left Venice mallow as the predominant weed (17% vs. 2% yellow foxtail). Acetochlor followed by postemergence applications, and imazamox + bromoxynil also reduced both weed species compared with the untreated control, but Venice mallow remained the main weed. At the second harvest, yellow foxtail was dominant across the entire field, and only acetochlor and bromoxynil did not reduce weed biomass. At both the first and second harvests, total forage dry matter yield (alfalfa + weeds) was greatest in nontreated plots (1,634 and 1,813 kg ha^{-1}) and reduced with imazamox + bromoxynil alone (1,016 and 1,195 kg ha^{-1}). Nontreated plots had lower CP at first and second harvests (15.2 and 14.9%) than herbicide-treated plots, where CP reached 19.3%. First-harvest RFV was greatest with acetochlor followed by imazamox + bromoxynil (158) and imazamox + bromoxynil (155), and lowest with bromoxynil alone (110) and nontreated control (121). Across treatments, each percentage-point increase in weed proportion decreased CP by 0.05-0.07% and RFV by 0.4-0.5 units, increased NDF by 0.13-0.14% and ADF by 0.04%, and increased total forage dry matter

yield by 5.6-7.1 kg ha^{-1}. These findings demonstrate that weeds can increase total forage dry matter yield while compromising nutritive value, highlighting the importance of considering both yield and quality when evaluating weed management strategies in newly seeded alfalfa.

97 - Evaluation of Sequential Herbicide Applications for Weed Control in Corn

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Determining the optimal timing of sequential postemergence (POST) herbicide applications in corn is essential to maximize the residual activity of preemergence (PRE) herbicides while maintaining effective weed control and minimizing unnecessary herbicide inputs. Early POST applications may overlap with the residual activity of PRE herbicides, while delayed applications may allow weeds to compete with the crop and reduce grain yield. This study aimed to evaluate the effects of sequential herbicide application timing on weed control and corn grain yield to support more efficient herbicide management strategies.

A field study was conducted at the Kansas State University Research Station at Ashland Bottoms, Kansas, from May to September 2026. The experiment was arranged in a randomized complete block design with four replications. All treatments received a PRE application of Acuron 3.44 ZC and Aatrex 4L. Treatment 1 received a full PRE rate (PRE_1X), while treatment 2 received the half PRE rate (PRE_1/2X), with neither receiving a sequential POST application. The remaining six treatments received the half PRE rate followed by a sequential POST application at 14, 21, 28, 35, 42 or 49 days after the PRE. POST applications consisted of a mix of Acuron 3.44 ZC, Aatrex 4L, a nonionic surfactant (NIS), and ammonium sulfate (AMS). Visual weed control ratings were collected throughout the growing season for Palmer amaranth (*Amaranthus palmeri*), morning glory (*Ipomoea* spp.), common sunflower (*Helianthus* spp.) and velvetleaf (*Abutilon theophrasti*) at 14, 28, 35 and 42 days after POST. Corn grain yield was taken at harvest for the treatments. Grain yield was analyzed using analysis of variance (ANOVA), including treatment and block effects, followed by Tukey's honestly significant difference test for mean comparisons. Visual ratings of Palmer amaranth and morning glory at 42 days after POST were evaluated using a block-stratified rank-based permutation test. Herbicide treatment affected corn grain yield ($P < 0.001$). The program with POST applied 49 days after PRE resulted in significantly lower grain yield (4.31 Mg ha^{-1}) than all other treatments. No significant differences were detected among the remaining treatments. The greatest numerical yield was observed with POST applied 42 days after PRE (11.37 Mg ha). Although not statistically different, PRE_1/2X presented a numerically lower yield (8.79 Mg ha^{-1}) than most sequential programs. Palmer amaranth control ratings remained consistently greater than 95% for all treatments, however morningglory control presented more variability. No significant treatment differences were detected at 42 days after POST evaluation for Palmer amaranth ($P = 0.285$) or morning glory ($P = 0.101$). Nevertheless, numerically lower morningglory control ratings were observed with PRE_1/2X and the sequential program at with POST applied at 21 days after PRE. These preliminary results indicate that herbicide application timing may influence corn grain yield, even when differences in visual weed ratings are not statistically significant. Further investigation of weed interference, crop

response, and species interactions is needed to explain the observed yield differences and improve sequential herbicide application strategies.

98 - Efficacy, Persistence, and Relative Environmental Risks of Acetochlor Alternatives in Corn and Soybean

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Acetochlor is a commonly used preemergence (PRE) herbicide that provides residual control of annual grasses and small-seeded broadleaf weeds in corn, soybean, sugar beet, and other crops. However, repeated detections of acetochlor in surface waters in Minnesota underscore the need to evaluate alternative PRE herbicides that maintain effective weed control and crop productivity while reducing environmental risks. Two field experiments were conducted at the University of Minnesota's Southern Research and Outreach Center (SROC) in Waseca, MN, in 2025 to evaluate weed control efficacy, soil persistence, and crop yields following PRE applications of six herbicides in corn (acetochlor, atrazine, clopyralid, isoxaflutole, mesotrione, and pyroxasulfone) and five herbicides in soybean (acetochlor [micro-encapsulated], dimethenamid-P, metribuzin, *S*-metolachlor, and sulfentrazone). Data from corn and soybean experiments were analyzed separately. Treatments were arranged in a randomized complete block design with four replications. Soil samples were collected 1 day before and at 0, 14, 28, and 56 days after PRE application and analyzed for herbicide residues using liquid chromatography-tandem mass spectrometry to evaluate soil persistence. Preliminary results in corn indicated that the parent compounds of clopyralid, isoxaflutole, and mesotrione were detected in soil only on the day of application, suggesting lower persistence than the other herbicides evaluated. Acetochlor and atrazine exhibited a similar persistence pattern throughout the season, while the percentage of pyroxasulfone remaining in the soil at 56 days after treatment (63.8%) was greater than that of acetochlor and atrazine (≤ 20.4%). Acetochlor and isoxaflutole provided the greatest weed control among the herbicides tested, resulting in the lowest total weed biomass (1.83 g m^{-2} and 1.05 g m^{-2}, respectively) across the four monitored species: *Setaria faberi* Herrm., *Ambrosia artemisiifolia* L., *Chenopodium album* L., and *Amaranthus tuberculatus* (Moq.) Sauer. Corn grain yield differed significantly among treatments. Acetochlor (12,701 kg ha^{-1}), isoxaflutole (12,517 kg ha^{-1}), and pyroxasulfone (12,067 kg ha^{-1}) produced the highest numerical yields, with no significant differences among these three treatments. In soybean, all herbicides exhibited relatively similar soil persistence patterns, with little to no detectable residues at 56 days after treatment. Weed control, both for individual species and overall, as well as soybean grain yield, did not differ significantly among treatments. Data collection was repeated in 2026 to complement the 2025 dataset and strengthen conclusions regarding weed control efficacy and herbicide persistence. Further research is needed to determine the broader environmental risks and contamination pathways associated with these PRE herbicides.

99 - Enclosa™: Expanding the Residual Weed Control Toolbox for Soybean

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Enclosa™ herbicide is a premix containing encapsulated acetochlor (Group 15) at 360 g ai L^{-1} and cloransulam (Group 2) at 7.5 g ai L^{-1} for preemergence or postemergence applications in soybean. Encapsulated acetochlor provides residual control of small-seeded broadleaves and grasses. Cloransulam provides residual and postemergence control of large-seeded broadleaves. Across 12 Corteva Agriscience trials conducted in 2026, Enclosa herbicide applied postemergence demonstrated excellent crop safety in soybean. Enclosa plus Liberty Ultra® (glufosinate-P-ammonium) caused 6 to 14% less crop injury at 1 week after application (WAA) than Warrant Ultra® (acetochlor + fomesafen) plus Liberty Ultra or Prefix® (S-metolachlor + fomesafen) plus Liberty Ultra. Enclosa plus Liberty Ultra provided equivalent or improved control of velvetleaf, morningglory, burcucumber, and cocklebur, with 3 to 12% greater control than competitive standards at 3 to 4 weeks after application. Compared with Enversa™ (encapsulated acetochlor) plus Liberty Ultra, Enclosa plus Liberty Ultra improved residual control of velvetleaf (+5%), morningglory (+4%), burcucumber (+9%), and cocklebur (+8%). Enclosa herbicide was launched by Corteva Agriscience in 2026 and is expected to be widely available for use in soybean production during the 2027 growing season. Enclosa herbicide is labeled for use at 2.3 to 4.7 L ha^{-1} (32 to 64 oz $acre^{-1}$). The product was developed to provide flexible application timing from preplant to R2 in soybean and residual control of more than 36 hard-to-control broadleaf and grass weeds.

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100 - Beyond Herbicide Residues: When does Glufosinate Application Timing and Rate Influence Grain Yield in Glufosinate-Resistant Soybean?

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Weed management in soybean [*Glycine Max* (L.) Merr] production is complicated by troublesome weeds, such as *Amaranthus* species, that have extended germination periods and evolved resistance to multiple

herbicide sites of action. Fortunately, glufosinate has been an effective option for postemergence (POST) control of several herbicide-resistant weed species. However, glufosinate product labels specify that glufosinate should not be applied during reproductive soybean growth. Currently, there is no published literature on the potential loss of soybean grain yield due to glufosinate applications from soybean flowering to maturity. In 2025 and 2026, field experiments were conducted at 11 locations across prominent soybean-producing states (AR, IN, IL, KS, MI, MO, ND, OH, TN, WI) to investigate the influence of glufosinate rate and application timing on glufosinate-resistant soybean. The experiment was designed as a randomized complete block design with four replicates. The two factors were glufosinate rate (370 g ai ha^{-1}, 448 g ai ha^{-1}) and application timing (V5/V6, R1, R2, R3, R4, R5). Plots were maintained weed-free with preemergence herbicides suitable for each geography and hand weeding. There were two sequential applications of L-glufosinate ammonium plus 5% v/v ammonium-sulfate, with all treatments receiving an application at V5/V6 soybean growth stage. Treatments with reproductive stage timings received a second application at one of the respective factorial application timings. Data collection included visual estimates of soybean injury at 3, 7, 14, 21, and 28 days after treatment (DAT) and soybean grain yield parameters. When pooled across all sites, neither glufosinate rate ($p=0.4264$) nor application timing ($p=0.1566$) impacted soybean grain yield. However, four individual states (MI, MO, OH, TN) had a significant ($p < 0.05$) interaction of glufosinate rate and application timing which decreased yield by 7% to 11% compared to the nontreated. Conversely, applications in Kansas increased yield by 13% to 66% compared to the nontreated. This may imply that a combination of specific application and environmental conditions negatively impacts grain yield when glufosinate is applied off-label during reproductive growth stages of glufosinate-resistant soybean. Therefore, it is crucial for growers to strictly follow herbicide labels and abide by growth stage restrictions to avoid both unlawful herbicide residues in grain and potential soybean yield loss.

101 - Investigating Glufosinate + 2,4-D Interactions to Improve Waterhemp Control

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Waterhemp *(Amaranthus tuberculatus)* is a highly competitive, fast-growing weed that poses significant management challenges in U.S. row-crop production systems. Herbicide-resistant waterhemp populations continue to expand, limiting the effectiveness of several herbicides. Although 2,4-D and glufosinate remain effective options for waterhemp management, the most effective application strategy for combining these herbicides, whether in tank mixtures or sequential applications, remains unclear. Therefore, this study evaluated the effectiveness of tank mixtures and sequential applications of glufosinate and 2,4-D for waterhemp control. Field experiments were conducted at the Field Extension Education Laboratory, Iowa State University, Ames, Iowa. Separate randomized complete block design trials with four replications were established. Treatments included glufosinate alone, 2,4-D alone, sequential applications of 2,4-D followed by glufosinate at 1, 4, 24, 48, 96, and 168 hours after treatment, glufosinate followed by 2,4-D at 24 hours after treatment, and a glufosinate plus 2,4-D tank mixture. Waterhemp control was evaluated visually at 28 days after treatment (DAT), and fresh and dry biomass

reductions were measured at 28 DAT. At 28 days after treatment (DAT), waterhemp control was visually assessed relative to the non-treated control, and aboveground biomass was harvested using a $1m^2$ quadrats and oven-dried until constant weight. Statistical analysis was performed using a linear mixed-effects model, where herbicide was considered a fixed effect, and replicate was a random effect. Means were separated using LSD at $\alpha = 0.05$. Waterhemp control ranged from 97.5% to 100% for all glufosinate-containing treatments and did not differ significantly among application timings. In contrast, 2,4-D applied alone provided 80% control and was significantly less effective than all treatments containing glufosinate. Fresh biomass reduction ranged from 56.8% to 89.2% across treatments. 2,4-D alone produced the lowest fresh biomass reduction (56.8%), while all glufosinate-containing treatments produced significantly greater reductions (88.6% to 84.2%). Similar trends were observed for dry biomass, where 2,4-D alone reduced biomass by 67.0% and was significantly less effective than treatments that included glufosinate. These results demonstrate that glufosinate was the primary contributor to waterhemp control, providing excellent efficacy regardless of application sequence or tank mixing with 2,4-D. Including glufosinate consistently improved visual control and biomass reduction compared with 2,4-D alone, suggesting that glufosinate-containing programs remain an effective management strategy for waterhemp control and may support resistance management through multiple herbicide sites of action.

102 - Response of a Fomesafen-Resistant Waterhemp (*Amaranthus tuberculatus*) Population to Foliar Applications of Trifludimoxazin

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Waterhemp (*Amaranthus tuberculatus*) is a major weed in the Midwestern United States that can rapidly shift toward populations resistant to multiple herbicide modes of action under recurrent herbicide selection pressure. Fomesafen, a protoporphyrinogen oxidase (PPO)-inhibiting herbicide, has been widely used to manage waterhemp in soybean production as waterhemp resistance to these herbicides continues to evolve. Trifludimoxazin, a next-generation PPO inhibitor, has been documented to retain efficacy against waterhemp populations carrying the most commonly reported PPO target-site resistance mutations, ΔG210 and R128G. This robust activity of trifludimoxazin has been attributed to the unique binding site for trifludimoxazin, with the PPO2 β-sheet backbone allowing strong inhibition by the herbicide. Therefore, the objective of this study was to characterize responses to fomesafen and trifludimoxazin in three waterhemp populations: a known susceptible population and two PPO-resistant populations carrying the ΔG210 mutation (Crawfordsville and Carlyle). Plants were treated with fomesafen (0 to 1,315 g ai ha^{-1}) or trifludimoxazin (0 to 12.5 g ai ha^{-1}), with 1% v/v crop oil concentrate. Visual control ratings were collected at 7 and 14 days after application (DAA), and aboveground biomass was collected at 14 DAA. The lethal dose (LD_{50}), the herbicide dose required to cause plant mortality in 50% of each population, was estimated from survival data. Relative to the susceptible population the Carlyle populations was 7.5- and 3.8- fold less sensitive to fomesafen and trifludimoxazin, respectively. This indicates that trifludimoxazin was impacted to a lesser extent than fomesafen in the Carlyle population, which was consistent with the previous research on waterhemp with the ΔG210 mutation. The Crawfordsville population was 9.1- and 8.3- fold less sensitive to fomesafen and trifludimoxazin,

respectively, which suggests the response of the Crawfordsville population is inconsistent with previous research that documented the efficacy of trifludimoxazin for these two known target-site mutations. Future research should investigate target-site and non-target-site resistance mechanisms in the Crawfordsville population.

103 - Winter Wheat Tolerance to HPPD-inhibiting Herbicides

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Repeated herbicide use in wheat (*Triticum aestivum* L.) has contributed to the evolution of herbicide-resistant weeds, highlighting the need for alternative herbicide modes of action. The 4-hydroxyphenylpyruvate dioxygenase (HPPD) inhibitors mesotrione and tembotrione effectively control broadleaf and grass weeds in corn but are not registered for use in wheat due to crop injury. Previous greenhouse studies identified wheat genotypes with differential sensitivity to mesotrione and tembotrione. This study evaluated the field tolerance of three winter wheat varieties (WBS, WHM, and WSL) to mesotrione and tembotrione across eight site-years in Kansas (three locations in 2025 and five in 2026). Mesotrione was applied at 0, 0.105 (corn field recommended rate), 0.210, 0.420, and 0.631 kg ai ha^{-1}, and tembotrione at 0, 0.092 (corn field recommended rate), 0.184, 0.368, and 0.552 kg ai ha^{-1}. Treatments were arranged in a split-block design with four replications. Variety was the main plot, and herbicide treatments were randomized within each variety. Visual injury (1, 2, and 3 weeks after treatment [WAT]) and heading height were assessed at all five locations in 2026, and grain yield was determined at three locations in 2025 and four in 2026. Data were analyzed using mixed-effects models analysis of variance, Tukey-adjusted mean comparisons ($\alpha = 0.05$), and nonlinear dose-response regression. At 3 WAT, WBS exhibited less visual injury than WHM and WSL at the highest rate under both herbicides ($P < 0.05$). Mesotrione (0.631 kg ai ha^{-1}) injury averaged 12%, 24%, and 32% for WBS, WHM, and WSL, respectively, compared with 21%, 30%, and 36% under tembotrione (0.552 kg ai ha^{-1}). Dose-response analysis for mesotrione indicated WBS (ED_{10} = 0.410 kg ai ha^{-1}) required 3.0- and 6.7-fold higher doses than WHM (ED_{10} = 0.138 kg ai ha^{-1}) and WSL (ED_{10} = 0.061 kg ai ha^{-1}), respectively. For tembotrione, WBS (ED_{10} = 0.135 kg ai ha^{-1}) required 3.5- and 2.6-fold higher doses than WHM (ED_{10} = 0.038 kg ai ha^{-1}) and WSL (ED_{10} = 0.052 kg ai ha^{-1}), respectively. At the highest rate, WBS exhibited the tallest mean heading height under mesotrione (21.35 inches) and tembotrione (21.38 inches), although variety-by-dose interactions were not significant. In 2025, grain yield declined with increasing rate under both herbicides ($P < 0.001$); however, WBS yielded more than WHM and WSL at 0.368 kg ai ha^{-1} tembotrione ($P < 0.05$). In 2026, mean grain yields at the highest rate were 52.79, 45.56, and 42.65 bu ac^{-1} under mesotrione and 58.51, 48.65, and 47.97 bu ac^{-1} under tembotrione for WBS, WHM, and WSL, respectively. Although WBS exhibited greater absolute grain yield, varietal differences in herbicide-induced yield loss were not significant in either year ($P > 0.05$). Overall, WBS demonstrated promising field tolerance to HPPD-inhibiting herbicides, particularly through reduced visual injury and greater heading height. Future research will focus on identifying quantitative trait loci (QTLs) associated with HPPD-inhibitor tolerance using WBS × WHM and WBS × WSL mapping populations. These findings provide a foundation for

breeding HPPD-inhibitor-tolerant wheat varieties, potentially expanding weed management options for wheat growers.

104 - Control of Italian Ryegrass (*Lolium perenne* ssp. *multiflorum*) Utilizing Sequential Spring Burndown Applications

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Italian ryegrass (*Lolium multiflorum*) is a major problematic weed in Kentucky no-till corn. The recent confirmations of glyphosate and ACCase resistance has made it even harder to control. Plants surviving a spring burndown often require additional applications before and sometimes after corn planting and emergence. Some farmers using ryegrass as a cover crop plan two applications rather than waiting for control failure. A 2026 field study at the University of Kentucky Research and Education Center in Princeton, Kentucky, evaluated planned two-pass burndown programs with and without residual herbicides. The study included four replications and an untreated check. Four burndown sequences were evaluated: glyphosate followed by glyphosate, glyphosate followed by paraquat, paraquat followed by paraquat, and paraquat followed by glyphosate. Glyphosate and paraquat were applied at 1.5 lb ae/a, and 0.75 lb ae/a per application, respectively, with 12 days between applications. Each sequence was combined with each of four residual programs: no residual; rimsulfuron 0.16 kg ha^{-1} plus thifensulfuron 0.16 kg ha^{-1} in the first application; S-metolachlor 1.5 kg ha^{-1}, mesotrione 0.19 kg ha^{-1}, plus atrazine 1.5 kg ha^{-1} in the second application; or both residual treatments at their respective timings. Visual ryegrass control was assessed at 16 and 30 days after the second application. Glyphosate followed by paraquat with the early residual treatment provided 97% control at 16 days and 93% at 30 days. The same sequence with both residual treatments provided 97% and 95% control, respectively. Paraquat followed by glyphosate without residual herbicides had the lowest numerical control, at 43% and 35%. Italian ryegrass control depended on the combination of burndown sequence and residual program.

105 - Evaluating glyphosate, paraquat, and diquat programs for annual ryegrass termination

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[1] The Ohio State University

A common winter cover crop species utilized within the Midwest and Eastern Corn Belt regions of the United States is annual ryegrass [*Lolium perenne* L. ssp. *multiflorum* (Lam.) Husnot]. While proven effective at improving soil health, reducing erosion, and suppressing weeds, this cover crop species has become challenging to manage and terminate. Insufficient control of these plants can pose problems that negatively impact the productivity of row crops. At the Western Agricultural Research Station in South Charleston, Ohio, a study was conducted to test the efficacy of different herbicide programs, including the viability of potential alternatives to paraquat. Syngenta, the producer of Gramoxone, a common product

option for this active ingredient, recently announced plans to cease production of this herbicide. As a result, alternative termination options may be needed. A randomized complete block design with four replications evaluated the following treatments: glyphosate, paraquat, diquat, glyphosate + saflufenacil, glyphosate + tiafenacil, paraquat + atrazine, paraquat + metribuzin, and diquat + metribuzin. The study was conducted before planting soybeans (*Glycine max* L.*)* in late April. Treatments were applied on April 23rd, and observations were made 11 and 36 days after treatment (DAT). During these evaluations, visual evaluations of control efficacy (0-100%) were measured. At the 11 DAT evaluation, the treatment with the highest control of ryegrass was paraquat + atrazine at 78% control, which was not different from paraquat alone at 76%. Paraquat + metribuzin was similar to glyphosate + saflufenacil, with 70% and 68% control, respectively. Glyphosate alone was different from paraquat + metribuzin but similar to glyphosate + safluenacil with 63% control. Glyphosate + tiafenacil had 60% efficacy, which was not different from glyphosate alone. Finally, diquat and diquat + metribuzin were the least effective and provided insufficient termination of ryegrass, with 34% and 30% control, respectively. At 36 DAT, the highest level of control came from paraquat + atrazine at 74%, followed by paraquat + metribuzin at 69%. Gramoxone and glyphosate were statistically the same as the most effective treatments at 66 and 65%, respectively. Glyphosate + saflufenacil was 49% effective, and similar to glyphosate + tiafenacil at 46% control. The diquat and diquat + metribuzin treatments essentially resulted in no control of the annual ryegrass and were ineffective for termination. Results from this study show that paraquat is an effective program for annual ryegrass termination, and the addition of a group 5 herbicide like atrazine or metribuzin can improve control compared to paraquat alone. Adding a group 14 herbicide (saflufenacil or tiafenacil) to glyphosate did not improve control compared to applications of glyphosate alone. Although, diquat is in the same chemical family and generally a similar herbicide to paraquat, it was the least effective herbicide and not a viable option for ryegrass termination.

106 - Comparison of Herbicide Programs in 2,4-D Resistant Waterhemp in Michigan

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Waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer) populations resistant to 2,4-D have recently been identified in Michigan, causing concerns regarding the lasting effectiveness of 2,4-D-based weed management programs in soybean (*Glycine max* L. Merr.). These populations are also resistant to glyphosate. The objective of this research was to evaluate multiple herbicide programs for management of 2,4-D resistant waterhemp populations. A field experiment was conducted in 2026 in Rosebush, MI, and was arranged as a randomized complete block with four replications. Herbicide programs consisted of a base program of flumioxazin (0.07 kg ha^{-1}) preemergence (PRE) followed by various postemergence (POST) treatments, including 2,4-D choline (1.07 kg ha^{-1}) alone, and with glyphosate (1.26 kg ae ha^{-1}), glufosinate (0.66 kg ha^{-1}), fomesafen (0.28 kg ha^{-1}), and in various combinations of these herbicides. Additional treatments included some of the previous combinations with acetochlor (1.26 kg ha^{-2}) for later season residual control. These treatments were compared with two standard programs for waterhemp control [flumioxazin (0.07 kg ha^{-1}) + pyroxasulfone (0.09 kg ha^{-1}) - PRE followed by glufosinate + glyphosate with and without S-metolachlor (1.39 ka ha^{-1}) POST], two POST applications of 2,4-D choline

as a control, and an untreated control. At the time of the POST application, 21 d after planting, flumioxazin provided 40% waterhemp control, while the combination of flumioxazin + pyroxasulfone provided 65% waterhemp control. There was 0.35 cm of precipitation within 14 d of planting, likely limiting herbicide incorporation. Adding glyphosate, glufosinate, or fomesafen to 2,4-D choline controlled waterhemp 49, 95, and 90%, respectively, 14 d after the POST application (DAT). The combination of glufosinate and fomesafen with 2,4-D choline did not improve control compared with the herbicides alone. The addition of acetochlor to 2,4-D choline + glyphosate did not improve waterhemp control at 14 DAT. The herbicide program of flumioxazin + pyroxasulfone PRE followed by glufosinate + glyphosate POST controlled waterhemp 96%, adding S-metolachlor to this program did not improve control 14 DAT. However, at 42 DAT the addition of acetochlor or S-metolachlor to POST glufosinate treatments reduced weed counts by an average of 47% compared with a single POST application of glufosinate, indicating the residual activity did provide some additional control. However, every treatment at 42 DAT, regardless of residual activity, provided <68% control due to new emergence and regrowth of waterhemp after the POST application. An additional glufosinate application was made 21 DAT to several of the treatments. The two-pass POST application of glufosinate provided 95% waterhemp control, regardless of the addition of glyphosate, 21 d after the second application. Overall, herbicide treatments relying on 2,4-D choline and glyphosate were ineffective, as expected due to resistance in the population. PRE herbicides provided limited control, likely due to insufficient rainfall following the PRE application. The addition of a POST application of any herbicide was not sufficient for season-long control even with residual activity. Treatments containing a two-pass POST application of glufosinate were the only programs that provided excellent, season-long control and were the most effective management option for 2,4-D-resistant waterhemp.

107 - The effects of variety, herbicide application timing, and herbicide program on annual ryegrass termination

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[1]The Ohio State University

Annual ryegrass [*Lolium perenne* L. ssp. *multiflorum* (Lam.) Husnot; also referred to as Italian ryegrass] is planted as a cover crop in the Eastern Corn Belt because of its rapid establishment and dense root system. However, spring termination can be inconsistent, and escapes may compete with the following cash crop. Termination success depends on ryegrass variety, application timing, and herbicide program, yet limited information exists evaluating these factors together. A field study was conducted over two seasons (2025 and 2026) at the Western Agricultural Research Station in South Charleston, Ohio, as a factorial randomized complete block (RCBD) design with four replications. Annual ryegrass was drilled on October 8, 2024 and October 15, 2025 at 16.8 kg ha^{-1}. Treatment factors were ryegrass variety (LowBoy, Winterhawk, and Tetraprime); application timing (early, 7 days preplant; and late, approximately 3 weeks after the early application); and herbicide program (glyphosate at 1,255 g ae ha^{-1} plus ammonium sulfate at 2.5% v/v; or paraquat at 1,267 g ai ha^{-1} plus non-ionic surfactant at 0.25% v/v). Early applications were made on April 24, 2025 and April 23, 2026, and late applications on May 12, 2025 and May 15, 2026. Control was visually rated (0-100%) three times in 2025 and in 2026. Data were analyzed with PROC GLIMMIX in SAS. The global F-test was used to evaluate significance. Treatment

means were separated using P values for differences of least significant means at $\alpha \leq 0.05$. In early 2025, there was a significant interaction between ryegrass variety and herbicide program. The early termination treatments evaluation found that Winterhawk variety had the highest control from glyphosate, followed by Tetraprime terminated with glyphosate, which was only greater than Tetraprime terminated with paraquat. In late 2025, significant interactions occurred between ryegrass variety and timing, and rye variety and herbicide. The greatest control occurred where ryegrass was terminated late, and lowest where LowBoy variety was terminated early. Winterhawk terminated by glyphosate had the greatest control, followed by Tetraprime with glyphosate. At this evaluation timing, treatments terminated early with paraquat and late with glyphosate were greater than late with paraquat, and neither were different than early with glyphosate. In both early and late evaluation timings of 2026, there was significant interaction between rye variety and termination timing, when greater control was reached with Winterhawk on both termination timings, and with Lowboy at the late termination timing. In both early and late evaluation timings of 2026, there was significant triple interaction between rye variety, herbicide program, and termination timing. Glyphosate showed greater control when compared to paraquat at the early termination timings for Winterhawk and Tetraprime, and at the late termination timing for Lowboy. Glyphosate was equal to or more effective than paraquat for all varieties, and Winterhawk terminated with glyphosate had the highest control in both seasons in June. Growers should consider avoiding terminating Lowboy early and Tetraprime late with either glyphosate or paraquat. Across seasons, ryegrass variety, timing and herbicide were consistent determinants of termination success. Growers using annual ryegrass as a cover crop in Ohio should consider variety when planning termination.

108 - Evaluation of Postemergence Herbicides for Control of Glufosinate-Resistant Waterhemp in Kansas

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Herbicide resistance in waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer) complicates postemergence (POST) weed management in Kansas and highlights the need to identify effective alternative herbicides. The objectives of this study were to evaluate the response of a glufosinate-resistant waterhemp population to glufosinate and assess the efficacy of existing and experimental POST herbicides relevant to crops grown in Kansas rotations, including corn, sunflower, sorghum, sugarbeet, and wheat. A greenhouse experiment was conducted at Kansas State University in Manhattan, Kansas, in a single run using a randomized complete block design to evaluate the responses of two waterhemp populations, a glufosinate-resistant population (GFA-R) and an acetolactate synthase inhibitor-resistant population (ALS-R), to 16 POST herbicide treatments, including two new BASF protoporphyrinogen oxidase (PPO)-inhibiting herbicides currently in development. Each herbicide treatment was evaluated at a single rate with treatment-specific adjuvants. Treatments were applied to plants 10-12 cm tall using a research track sprayer calibrated to deliver 140 L ha^{-1}. The experiment included six replications for GFA-R and four replications for ALS-R. Weed control was assessed at 1, 2, 3, and 4 weeks after treatment (WAT) on a scale of 0% to 100%, where 0% indicated no control and 100% indicated complete plant

death. Data were subjected to analysis of variance separately at each assessment, and treatment means were compared using Tukey's significant difference test. A population × herbicide treatment interaction was detected at all assessment timings ($P < 0.001$). At 4 WAT, topramezone (0.049 kg ai ha^{-1}), topramezone plus atrazine (0.049 + 0.280 kg ai ha^{-1}), saflufenacil plus trifludimoxazin (0.0255 + 0.0128 kg ai ha^{-1}), and BASF’s new PPO-inhibiting herbicides trifludimoxazin and fendioxypyracil (each at 0.025 kg ai ha^{-1}) provided 99% weed control in both populations. Similarly, glufosinate-P-ammonium plus 2,4-D (0.370 kg ai ha^{-1} + 1.065 kg ae ha^{-1}) provided 98% and 99% control of GFA-R and ALS-R, respectively. Glufosinate-P-ammonium alone (0.370 kg ai ha^{-1}) provided 77% and 99% control of GFA-R and ALS-R, respectively, whereas 2,4-D alone (1.065 kg ae ha^{-1}) provided less control (67% and 48%). Dicamba (0.560 kg ae ha^{-1}), dicamba plus diflufenzopyr (0.140 + 0.0560 kg ae ha^{-1}), and mesotrione (0.105 kg ai ha^{-1}) provided similar control to 2,4-D alone, with 62%, 47%, and 50% control of GFA-R and 76%, 55%, and 51% control of ALS-R, respectively. Glyphosate (1.261 kg ae ha^{-1}), imazamox (0.0438 kg ae ha^{-1}), and metsulfuron-methyl (0.0042 kg ai ha^{-1}) each provided less than 35% control of both populations. Population differences were not significant for these treatments. In contrast, saflufenacil alone (0.025 kg ai ha^{-1}) provided 36% control of GFA-R and 99% control of ALS-R. The developmental PPO-inhibiting herbicides trifludimoxazin and fendioxypyracil, along with selected existing POST treatments, showed promise for controlling glufosinate-resistant waterhemp. However, incomplete control with several currently available herbicides highlights potential gaps in POST management options across Kansas cropping systems. Further research is needed to evaluate promising treatments across application rates and under field conditions as components of crop-specific weed management programs integrating preemergence and postemergence herbicides.

109 - Stacking PPO Herbicides in Soybean: What to Expect.

Mark VanGessel[1], Dwight Lingenfelter[2], Barbara Scott[1]

[1]University of Delaware, [2]Penn State University

Protoporphyrinogen oxidase (PPO)-inhibiting herbicides are important tools for managing broadleaf weeds in soybean (*Glycine max* (L.) Merr.) production. Products containing sulfentrazone or flumioxazin are commonly applied at planting for residual weed control, while lactofen and fomesafen are applied postemergence. Increasing reliance on PPO herbicides, particularly in non-GMO soybean production systems, has led to greater interest in sequential applications of PPO herbicides. However, limited research has examined the impact of multiple PPO applications on soybean crop safety and yield. This study was a factorial arrangement of preemergence and postemergence herbicides using a randomized complete block design with four replications. Preemergence treatments included sulfentrazone, flumioxazin, or no preemergence herbicide. Postemergence treatments included lactofen, fomesafen, or glyphosate plus glufosinate. Herbicides were applied using a precision sprayer delivering 15 gal/A, with preemergence treatments applied immediately after planting and postemergence treatments applied at the three- to four-trifoliate stage. Glyphosate plus 2,4-D choline was broadcast to maintain weed-free conditions. Penn State location also utilized a late postemergence timing with applications made after flowering. Soybean injury was evaluated following emergence and after postemergence applications and plots were harvested. At the Delaware location, preemergence sulfentrazone and flumioxazin caused 13% and 8% soybean injury, respectively. Postemergence leaf burn was greatest with lactofen (41%), followed

by fomesafen (17%), while glyphosate plus glufosinate caused minimal injury (1%). Two weeks after postemergence applications, soybean injury was greatest with lactofen (53 to 60%), compared with 16 to 25% for fomesafen and 4 to 8% for glyphosate plus glufosinate. Four weeks after treatment, plots treated with fomesafen or glyphosate plus glufosinate had recovered to less than 10% while injury averaged 28% with lactofen. Soybean yield was similar following glyphosate plus glufosinate (3,564 kg/ha) and fomesafen (3,362 kg/ha) treatments, and both produced greater yields than lactofen (2,959 kg/ha). Additional data will be presented in the oral presentation.

110 - Improving Grain Sorghum Tolerance to Mesotrione Through Optimization of Fluxofenim Safener and Herbicide Rates.

Brenna Chism[1], Yasir Parrey[1], Sarah Ganske[1]

[1]Kansas State University

Grain sorghum (*Sorghum bicolor* (L.) Moench) is the world's fifth most widely produced cereal crop, valued for its resilience under harsh environmental conditions and its contribution to food and nutrition security, particularly in arid and semi-arid regions. However, weed management remains challenging due to limited herbicide options, particularly for postemergence (POST) control of grass weeds and other troublesome species. Herbicide safeners enhance crop tolerance to specific herbicides by stimulating detoxification pathways involving cytochrome P450 monooxygenases and glutathione S-transferases (GSTs). Fluxofenim, a widely used sorghum seed-treatment safener, has been shown to mitigate grain sorghum injury caused by *S*-metolachlor. However, its potential to protect sorghum from injury following POST applications of mesotrione remains unreported. This study evaluated fluxofenim seed treatment rates to minimize mesotrione-induced crop injury to assess the potential for expanded POST herbicide options in grain sorghum. A greenhouse experiment was conducted using commercial grain sorghum hybrids El Mota, P84G62, RTx430, SC405, SC420, and SC991. Each received fluxofenim seed treatments at the recommended rate of 0.4 g a.i. kg^{-1} seed, 0.8 g a.i. kg^{-1} seed, or no safener before mesotrione application at the 2-3-leaf stage. Treatments were arranged in a randomized complete block design with four replications, and the experiment was repeated in time. Herbicide injury and chlorophyll index were visually assessed at 1, 2, 3, and 4 weeks after treatment (WAT), while aboveground biomass was collected at 4 WAT, dried and then measured to quantify crop responses. Data were subjected to analysis of variance, and means were separated using Tukey's honestly significant difference (HSD) test to compare treatment effects within each genotype. Treatment responses varied among sorghum genotypes and measurement periods. Safener treatments differed for visual injury and SPAD readings in several genotype-week combinations; however, differences between the 1x and 2x safener rates were generally limited. SPAD measurements differed significantly among treatment combinations in RTx430, SC405, and SC420, with differences of 7.7-19.4 units. Dry weight responses also varied by genotype, with the nontreated sorghum producing greater dry weight than other treatment combinations in RTx430, SC405, and SC991. Overall, increasing the safener rate did not consistently result in improved chlorophyll retention or biomass accumulation across genotypes. Further research is needed to clarify the inconsistent treatment responses observed among genotypes and to establish the reliability of fluxofenim as a tool for expanding POST herbicide options in grain sorghum.

111 - Determining Length of Residual Control for Pre-Emergence Herbicides in Iowa

Rocco D'Antico[1], Wesley Everman[1], Damian Franzenburg[1], Iththiphonh Alex Macvilay[1], Estefania Gomiero Polli[1], Tunde Akanbi[1], Caroline Wayhs Backes[1], Steven Tri[1]

[1]Iowa State University

As resistance to common, post-emergence herbicides increases across our state, the importance of comprehensive management programs increases. Cascading applications of multiple products provide continuous protections against weedy competition and resistant evolution. Such programs most commonly begin prior to crop emergence, with a variety of chemistries and combinations. Analyzing their effect on select, noxious species benefits regional producers contending with these weeds. This study included products commonly applied in corn (*Zea mays*) and soybean (*Glycine max*) fields, separated into two experiments. These were arranged as in-field, randomized plot (3.0m by 7.6m size) designs with four replications, located in separate fields at Iowa State University in Ames, Iowa, United States. Seven individual and five pre-mixed corn treatments, as well as a non-treated check, were applied at planting and evaluated 21, 28, and 42 days after application (DAA). Similarly, five individual and six pre-mixed soybean treatments were applied evaluated 21 and 28 DAA. The corn field presented consistent ivyleaf morningglory (*Ipomoea hederacea*), velvetleaf (*Abutilon theophrast*), and waterhemp (*Amaranthus tamariscinus*) pressure; the soybean field presented the same species, with the addition of giant foxtail (*Setaria faberi*). In corn, acetolachlor, atrazine, mesotrione, pyroxasulfone, and s-metolachlor provided 99% control of velvetleaf and common waterhemp at 42 DAA, while morningglory control at 42 DAA was highest with pyroxasulfone (96%), s-metolachlor (93%), and mesotrione (93%). In soybean, control at 21 DAA was strong for giant foxtail (89-99% across treatments) and common waterhemp (84-99% for most treatments), but velvetleaf and especially morningglory were less consistently controlled. By 29 DAA in soybean, several treatments maintained high control of giant foxtail, velvetleaf, and waterhemp, whereas morningglory remained variable, ranging from 0% with metribuzin to 88% with sulfentrazone.This research serves as an important benchmark for comparing pre-emergence effectiveness across individual products and pre-mixes. Additionally, it highlights the importance of multiple modes-of-action when battling many species. Subsequent studies may seek to include different weed pressure and identify the efficacy of fall applications.

112 - Influence of Winter Wheat Residue on Preemergence Herbicide Programs Containing Diflufenican in Soybeans

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Waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer) is among the most problematic weeds in soybean (*Glycine max* (L.) Merr.) production. Diflufenican (DFF), a Group 12 phytoene desaturase-inhibiting

herbicide, offers a new site of action with soil residual activity against waterhemp. However, DFF is associated with a unique foliar response resulting in soybean leaf bleaching, typically following rainfall. The role of soil residue on DFF foliar bleaching severity is not well understood. Therefore, this study examined whether winter wheat (*Triticum aestivum* L.) residue would intercept rainfall and limit soil-to-leaf herbicide movement, potentially reducing DFF-induced bleaching, while simultaneously suppressing emerging weeds. This study evaluated the influence of winter wheat residue on DFF-based residual herbicide efficacy, soybean bleaching, stand establishment, and yield. Field experiments were conducted in 2025 and 2026 in Belleville, Illinois, using a split-plot randomized complete block design with four replications. Winter wheat presence/absence was the whole-plot factor, with herbicide treatments randomized within each wheat treatment. Preemergence (PRE) treatments included (1) DFF (149 g ai ha^{-1}) alone or combined with the following active ingredients and rates: (2) metribuzin (280 g ai ha^{-1}); (3) flumioxazin (87.4 g ai ha^{-1}); (4) [flumioxazin (87.9 g ai ha^{-1})+pyroxasulfone (111.6 g ai ha^{-1})]; (5) [flumioxazin (87.7 g ai ha^{-1})+pyroxasulfone (112.1 g ai ha^{-1})+metribuzin (263.1 g ai ha^{-1})]; (6) acetochlor (1,267 g ai ha^{-1}); (7) flumioxazin (87.4 g ai ha^{-1})+metribuzin (280 g ai ha^{-1}); (8) acetochlor (1,267 g ai ha^{-1})+metribuzin (280 g ai ha^{-1}); plus a non-DFF-containing treatment of (9) [flumioxazin (87.7 g ai ha^{-1})+pyroxasulfone (112.1 g ai ha^{-1})+metribuzin (263.1 g ai ha^{-1})]; and (10) a nontreated check. In 2025, treatments containing DFF and flumioxazin, and DFF+acetochlor+metribuzin had lower waterhemp density than [flumioxazin+pyroxasulfone+metribuzin ($P<0.001$). In 2026, waterhemp density did not differ among herbicide programs but was reduced in plots with wheat residue ($P<0.001$). Total weed biomass showed an herbicide × wheat residue interaction in 2025 ($P=0.012$), with DFF+flumioxazin+metribuzin resulting in less biomass than DFF+acetochlor and [flumioxazin+pyroxasulfone+metribuzin] in plots without wheat residue. In 2026, DFF alone plots contained more weed biomass than DFF+[flumioxazin+pyroxasulfone+metribuzin], DFF+flumioxazin+metribuzin and [flumioxazin+pyroxasulfone+metribuzin] without DFF ($P=0.002$). In 2025, soybeans emerged on July 4th with a 2 cm rainfall occurrence within days. Contrary to expectations, bleaching at 7 DAE was greater in wheat residue than without ($P<0.001$) across DFF programs; bleaching was greatest with DFF+acetochlor and least with DFF+[flumioxazin+pyroxasulfone], whereas [flumioxazin+pyroxasulfone+metribuzin] without DFF caused no bleaching. By 21 DAE, soybean injury was no longer evident. In 2026, there was 2.5 cm of rain prior to emergence; overall injury (bleaching + stunting) was minimal throughout the duration of the season. Wheat residue reduced soybean stands in both years ($P<0.001$) but did not affect grain yield ($P=0.16$). An herbicide x wheat residue interaction affected yield in 2026 ($P=0.003$); without wheat residue, all programs exceeded the nontreated check, while DFF alone yielded less than several herbicide combinations, likely due to greater weed biomass. These findings indicate that DFF tank mixtures improve waterhemp suppression, and that winter wheat residue may increase overall crop injury in some treatments without compromising grain yield.

113 - Fenclorim Seed Treatment Safening of Pyroxasulfone Across Wheat Varieties

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[1]UPL-Ltd

Pyroxasulfone is an established residual herbicide used across weed management programs. Increasing weed resistance to acetolactate synthase (ALS)- and acetyl-CoA carboxylase (ACCase)-inhibiting herbicides among economically important grassy weeds has increased the need for options such as pyroxasulfone. Pyroxasulfone is labeled for preplant, pre-emergence, and delayed pre-emergence applications in wheat. Although delayed pre-emergence applications are generally safe for wheat, grassy weeds can germinate alongside the crop and emerge before adequate rainfall incorporates the herbicide. Preplant and pre-emergence applications can better align herbicide placement with early weed germination, although crop safety at these timings is less consistent and can vary among wheat varieties. Fenclorim is a herbicide safener seed treatment that improves wheat tolerance to pyroxasulfone. In winter wheat evaluations, fenclorim was safe when applied alone or with pyroxasulfone and reduced crop response to preplant and pre-emergence applications under a range of environmental conditions. Differences in inherent pyroxasulfone tolerance among varieties highlight the importance of evaluating varietal responses to the pyroxasulfone-fenclorim combination to determine the consistency and extent of crop protection. By reducing the risk of crop response from preplant and pre-emergence pyroxasulfone applications, fenclorim seed treatment may give wheat growers greater flexibility to position the herbicide before weed emergence. This approach offers an opportunity to improve crop safety while expanding the practical application window for effective weed management.

256 - A Multistate Comparison of Glufosinate Formulation

Glenn Nice[1], Oluseyi Ajani[2], Colin Barclay[3], Kevin Bradley[4], Matheus Luiz de Paula[5], Ryan DeWerff[6], Alyssa Essman[3], Karla Gage[7], Sarah Ganske[5], Aaron Hager[8], Jeremie Kouame[5], Travis Legleiter[9], Eric J Miller[7], Thomas C Mueller[10], Jason K Norsworthy[2], Simardeep Singh[4], Christy Sprague[11], Larry Steckel[10], Rodrigo Werle[6], Bryan G Young[12], Caleb Wepprecht[8], Jesse Yount[4], Joseph Ikley[1]

[1]North Dakota State University, [2]University of Arkansas, [3]The Ohio State University, [4]University of Missouri, [5]Kansas State University, [6]University of Wisconsin - Madison, [7]Southern Illinois University, [8]University of Illinois, [9]University of Kentuckey, [10]University of Tennessee, [11]Michigan State University, [12]Purdue University

Glufosinate is uniquely positioned to be a valuable tool in agriculture, having broad spectrum weed control and relatively few reported resistant weeds. This success has seen an increase in products using glufosinate as their active ingredient. However, efficacy can be affected by environmental conditions and weed spectrum. A study was conducted across 16 locations in 11 states to identify possible differences in proprietary formulation and region. Product names are being used to account for unknown proprietary components. Liberty® 280, Liberty® Ultra, Interline®, Interline® Mega, Cheetah® and Surmise® 5 were applied to deliver equivalent 656 g ha^{-1} of glufosinate. Ammonium sulfate was included at regionally recommended rates. Northen and in some cases western regions tended to have more variable control across formulations 14 days after treatment (DAT). Grass control at 7 DAT was equivalent across Liberty® 280, Liberty® Ultra, Interline®, Interline® Mega, Cheetah® formulation ranging from 83 to 85% control across locations and weed species. Treatments controlled *Amaranthus tuberculatus* from 84 to 94% 7 DAT over 5 locations. Arkansas and Kansas reported *Amaranthus palmeri* control lower than two sites in Tennessee 7 DAT; reporting means of 72 and 81% respectively. The two sites in Tennessee reported mean control over 85%. However, when combined over location, Surmise® 5 had less control

than Cheetah®, Interline® and Liberty® 280. Liberty® 280, Liberty® Ultra, Interline®, Interline® Mega and Cheetah® provided control of *Chenopodium album* ranging from 86 to 95% control at 14 DAT. *Bassia scoparia* was evaluated at two sites in North Dakota. The western site reported a 34% increase in control than the eastern site at 86% averaging over treatment. Liberty 280 provided the highest percent control of *Bassia scoparia* at each of the two locations 7 and 14 DAT. This study will be repeated in 2027.

Student Poster Contest – Weed Biology and Ecology

114 - Germination Responses of Wisconsin Waterhemp (*Amaranthus tuberculatus*) Populations to Environmental Conditions

Ahmadreza Mobli[1], Rodrigo Werle[1]

[1]University of Wisconsin- Madison

Waterhemp [*Amaranthus tuberculatus* (Moq.) J.D. Sauer; Family Amaranthaceae] is currently ranked as one of the most difficult-to-control weed species in Wisconsin cropping systems and other regions of the U.S. Midwest. Understanding waterhemp germination responses under different environmental conditions can provide valuable information to support management decisions and improve weed management strategies in Wisconsin cropping systems. A series of controlled-environment experiments were conducted to examine the germination ecology of 11 waterhemp accessions collected across corn and soybean production regions of Wisconsin. Waterhemp seeds germinated over a broad range of temperatures. Under constant temperatures, germination increased from 10 C (10.6%) to 25 C (73.5%) and 30 C (75.1%) and declined at 35 C (60.8%) and 40 C (32.2%). Under alternating day/night temperatures, germination was greatest at 30/15 C (84.0%) and 30/20 C (88.0%) under light/dark conditions. Under continuous darkness, the greatest germination occurred at 25/10 C (82.0%), 25/15 C (86.0%), and 30/20 C (88.0%). Germination occurred over a wide range of pH levels, with the greatest germination at pH 6 (80.1%) and pH 7 (79.7%) and the lowest at pH 4 (<1%). Germination declined under more alkaline conditions, reaching 60.6% at pH 10. Germination decreased with increasing salinity, from 89% at 0 dS m^{-1} to 40% at 12 dS m^{-1} and 13% at 16 dS m^{-1}, with no germination observed at salinity levels greater than 16 dS m^{-1}. Similarly, decreasing water potential substantially reduced germination, from 84% at 0 MPa to <1% at −1.0 to −1.2 MPa. Seedling emergence was greatest from shallow burial depths of 0.5 cm (87%) and 1 cm (84%), and no emergence was observed from depths greater than 4 cm. The ability of waterhemp to germinate across a broad range of environmental conditions and emerge from shallow soil depths should be considered when developing management strategies for this weed species.

115 - The Effect of Simulated Soybean Chaff Lines on Weed Seed Survival and Germination

Amber Emmons[1], Daniel Doretto[1], Mercy Odemba[1], Ram Yadav[1], Alssa Essman[1], Eugene Law[1]

[1]The Ohio State University

Understanding the weed seed bank offers a different way to plan for future weed management in an agronomic setting. Harvest weed seed control (HWSC) is an emerging strategy being evaluated in Ohio to combat the inputs of weed seed banks. One method of HWSC is chaff lining, where chaff is deposited in a narrow windrow, to concentrate the deposit of new weed seeds across a smaller area. This potentially creates an inhospitable environment for the weed seed to overwinter and then allows for targeted weed management strategies the next growing season. Seed survival in simulated soybean chaff windrows was evaluated in 2024-2025 and 2025-2026 in a controlled trial. Plastic trays were used, containing 500 weed seeds, soilless media, and one of the six chaff levels which represent differing soybean yields: 0 chaff (control), 1345 kgha-1 (20 bu/ac soybeans), 2690 kgha-1 (40 bu/ac), 4035 kgha-1 (60 bu/ac), 5380 kgha-1 (80 bu/ac), and 6725 kgha-1 chaff (100 bu/ac). The chaff was collected from clean soybean fields harvested at the Western Agricultural Research Station (WARS) in South Charleston, Ohio. Four troublesome species with varying seed sizes were selected: waterhemp (*Amaranthus tuberculatus* [Moq.]), giant ragweed (*Ambrosia trifida* [L.]), giant foxtail (*Setaria faberi* [Hermm.]), and yellow foxtail (*Setaria pumila* [Poir.]). Four trays with no added weed seeds were also utilized as a control to evaluate any weed seeds present in the chaff. The trial was set up outside on October 31st, 2025, and October 31st, 2026. The trays were allowed to overwinter, exposed to ambient environmental conditions, at Waterman farm in Columbus, Ohio. Both years in mid-March the trays were moved into the greenhouse prior to germination. Germination counts were conducted twice a week and any additional weed species that germinated were counted and noted. Data analysis was completed in RStudio and the negative binomial model was used to analyze differences in emergence for each species. In the 2024-2025 trial, waterhemp at the highest chaff rate was the only species x chaff rate combination to demonstrate a significant reduction in germination. No species reached full germination rates of 100 percent. In the 2025-2026 winter, waterhemp and yellow foxtail had no significant germination reductions at any chaff level. Giant ragweed presented significant increases in germination at the 1345 kgha-1 and 4035 kgha-1 rates while giant foxtail had significant increases of germination at the 2690 kgha-1 and 5380 kgha-1 rates. The control flats did not exhibit germination of any of the 4 weed species evaluated. The tested chaff weights did not reliably reduce weed seed germination. Chaff may protect the weed seeds from movement and predation and allow for higher rates of germination depending on environmental conditions. Also, weed seed germination is highly variable among the species in this study. Over the 2026-2027 winter, this trial will be repeated again to further determine the effects of differing chaff lining on weed seed survival.

116 - Advancing Soil Seedbank Characterization with Deep Learning-Based Weed Seed Detection and Identification

Emmanuel G Cooper[1], Tianzhang Zhao[1], Julie M Young[1], Jian Jin[1], Bryan G Young[1], Thomas R Butts[1]

[1]Purdue University

The soil weed seedbank serves as a reservoir for future weed infestations and is a key focus for integrated weed management. However, conventional seedbank assessment methods are labor-intensive and difficult to scale, creating a need for rapid and automated characterization tools to support proactive weed management decisions. This study evaluated the use of deep learning-based object detection for automated detection and identification of giant ragweed (*Ambrosia trifida*) and waterhemp (*Amaranthus tuberculatus*) seeds from soil imagery. Soil-seed mixtures were constructed using contrasting sandy and

clay soil backgrounds to simulate agricultural soil samples. For initial model development, giant ragweed and waterhemp seeds were manually placed on the soil surface and imaged under controlled conditions. Images were acquired using a 200-MP smartphone camera (Samsung Galaxy S23 Ultra) mounted on a custom 3D-printed imaging platform measuring approximately 16.5 × 15.2 cm. The platform maintained a fixed camera height approximately 20 cm above the soil surface. All images were captured in a nadir orientation, with the camera positioned directly above the sample to minimize variation in viewing angle and image geometry. Subsequently, the images were manually annotated with species-specific bounding boxes to create training datasets. Three YOLO11n object detection models were developed using sandy-soil, clay-soil, and combined-soil datasets. For the combined dataset, 354 annotated images containing approximately 10,145 weed-seed instances were divided into training (70%), validation (20%), and testing (10%) subsets. Transfer learning from pretrained YOLO11n weights was used to train models for 200 epochs using high-resolution image inputs, while image augmentation techniques including random flipping and rotation were applied to improve model robustness to variations in seed orientation and background conditions. Model performance was evaluated using held-out test datasets. Detection accuracy was assessed using mean Average Precision (mAP), a standard object-detection metric that accounts for both correct seed identification and accurate localization within an image. The sandy-soil model achieved a test mAP50 of 0.976 and mAP50-95 of 0.683, while the clay-soil model achieved mAP50 and mAP50-95 values of 0.971 and 0.743, respectively. The combined-soil model, trained on both soil background types, achieved a precision of 0.918, recall of 0.903, mAP50 of 0.905, and mAP50-95 of 0.621 on a test dataset containing 39 images and 1,110 annotated seed instances. This indicates that despite differences in soil background composition, all models achieved strong detection performance, meaning that weed seed characteristics can be effectively learned and distinguished from surrounding soil features. These results support the feasibility of developing robust computer vision workflows for rapid characterization of soil seedbanks and lay the foundation for evaluating model performance under more realistic field-derived soil samples. Ongoing research is evaluating these models using independently collected soil samples containing mixed soil backgrounds and minimally processed seed mixtures to assess model robustness under realistic soil seedbank conditions.

117 - Evaluation of Desiccants for Inducing Waterhemp (*Amaranthus tuberculatus*) Seed Shatter

Rebecca Stup[1], Rodrigo Werle[1], Milos Viric[1], Sarah Kezar[1]

[1]University of Wisconsin-Madison

Waterhemp [*Amaranthus tuberculatus* (Mog.) Sauer] retains a majority of its seed at the time of soybean harvest. Combines are known to spread weed seeds up to 145 meters beyond the edge of a weed patch, increasing yield losses in adjacent areas. Thus, the timing of seed shattering presents an opportunity for carefully timed management. The application of defoliants may stimulate shattering and reduce seed dispersal by combines within and across fields, and, to our knowledge, no studies have evaluated the effect of desiccant on seed shatter using broadcast or targeted applications. A greenhouse study was conducted in a factorial completely randomized design with four replications and two experimental runs beginning in July 2026. The first factor compared treated and untreated female waterhemp plants. A total of fourteen products were screening, spanning over categories such as systemic POST, contact herbicides,

desiccants, products that are both PRE-emergence herbicides and desiccants, and PRE-emergence herbicides. The second factor was the reproductive stage at the time of application, which was either seed development (green seed) or seed maturity (black seed). Applications were made with a backpack sprayer between 45 and 50 cm above the canopy. At 7 days after application, paper bags were added to each individual inflorescence to capture and quantify the number of shattered seed until harvest. At physiological maturity, female plants were harvested and shattered seed was separated from seed still attached to the inflorescence. Percent seed retention was determined by the following equation: % seed retention = (total no. of retained seed)/(total no. of retained seed + total no. of shattered seed). Seed was cleaned and dried to collect total seed biomass, thousand seed weight, and total seed production per plant. Future data collection includes testing germination, seed viability, and the vigor of the F1 generation. Results are anticipated to inform shattering-inducing applications prior to soybean harvest to reduce both seed viability and dispersal through combines, addressing a critical gap in integrated weed management.

118 - Friend or Foe? What We Know about Chinese Fountain Grass in Missouri

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[1]University of Missouri

Chinese fountain grass (*Cenchrus alopecuroides*) is an ornamental perennial grass that can escape cultivation and establish in pastures and roadside areas. Its potential to spread into pastures creates concerns for farmers seeking to maintain desirable forage species. In Missouri, tall fescue (*Lolium arundinaceum*), is the most common forage species utilized in pastures and haylands, and there are few selective herbicides available for the control of unwanted grasses in these environments. Two field experiments were conducted in 2017 and 2025 to evaluate different herbicide management approaches, herbicide active ingredients, and application timings for the control of Chinese fountain grass in tall fescue pastures. In 2017, broadcast applications of sulfosulfuron, glyphosate, nicosulfuron plus metsulfuron methyl, imazapic, imazapyr, clethodim, and fluazifop were compared along with repeated close mowings. Visual control and tall fescue injury ratings were conducted 14, 28, 70, and 150 days after treatment (DAT). The experiment conducted in 2025 compared spring, summer, and fall high-volume spot-spray applications of glyphosate, quinclorac, fluazifop, imazapic, imazethapyr, and hexazinone. Visual control and injury ratings were conducted at regular intervals through 365 DAT. In the 2017 experiment, broadcast applications of glyphosate (1442 g ha^{-1} and 2934 g ha-^{1}) provided 85 to 92% Chinese fountain grass control 150 DAT, while all other herbicide treatments provided 27% control or less. However, broadcast applications of glyphosate also resulted in 73 to 75% tall fescue injury. In the 2025 experiment, spot-spray applications of several herbicides provided excellent Chinese fountain grass control, but substantial differences in tall fescue injury. Spring applications of glyphosate, imazapic, and imazethapyr provided 100% Chinese fountain grass control at the final evaluation but resulted in 71 to 99% tall fescue injury. In contrast, spring and summer spot-spray applications of quinclorac provided at least 90% Chinese fountain grass control with only 3 to 7% tall fescue injury. Overall, these results indicate that few herbicide options are available for the selective control of Chinese fountain grass in tall fescue pastures, but spot-spray applications of quinclorac may provide an effective management option

with minimal injury to the desirable forage. Future research should evaluate whether broadcast applications of quinclorac could provide similar levels of Chinese fountain grass control.

119 - Soil Microbiome Assembly by *Sorghum halepense* (Johnsongrass): Implications for Plant Performance and Invasion Success

Connor Purvis[1], Chris Blackwood[1], Erin Burns[1]

[1]Michigan State University

Herbicides remain the cornerstone of weed management in agricultural systems; however, the rapid evolution and spread of herbicide resistant weeds have challenged their long-term efficacy and increase the need for alternative management strategies. Soil microorganisms play an important role in nutrient cycling, plant productivity, and soil health. Notably, *Sorghum halepense* has demonstrated its ability to modify the soil microbiome especially under poor conditions for its persistence. Understanding weed-microbe interactions would provide significant insights into how they contribute to weed success. Given these factors, we had three objectives: 1) determine the influence of soil legacies created by *S. halepense* on subsequent *S. halepense* infestations, 2) examine the impact of *S. halepense* on the soil bacterial community composition, and 3) identify important microbial taxa for *S. halepense* performance and persistence. A greenhouse plant-soil feedback (PSF) experiment was conducted at Michigan State University as a factorial randomized complete block design with four replications and repeated twice. Factors included: soil type [live-infested (LI), sterilized live-infested (LIS), and potting soil (PS)], soil conditioning treatments [established infestation (EI), unestablished infestation (UI), and no infestation (NI)], and biotype [southern (KY) and northern (MI)]. A 5-month soil conditioning phase simulated *S. halepense* infestation, followed by a 5-month feedback phase evaluating subsequent plant performance. Plant height was measured every 4 weeks after planting (WAP) and aboveground biomass was harvested at 20 WAP. Soil samples collected after each phase were subjected to 16S rRNA gene sequencing to characterize bacterial community composition; raw reads were processed through DADA2 pipeline in R and taxonomic classification performed against the SILVA database. Results demonstrated stark differences in aboveground biomass and plant height between soil conditioning treatments and soil type; however, no differences were observed between biotypes. Specifically, plants in the NI treatment produced 72% more biomass than those in EI or UI ($p<0.01$). However, within EI and UI, biomass was approximately 10% greater in LI soils than in LIS or PS soils, suggesting that live soil communities partially mitigated the negative effects of prior infestation. Similar patterns were observed for plant height. Although soil type and sample timing primarily drove bacterial responses, soil conditioning also significantly shifted the bacterial community ($p=0.01$). Interestingly, both biotypes shifted the community similarly compared to no conditioning treatments. Moreover, the majority of taxa positively associated with plant performance were linked to LI soils (94%), warranting functional investigation of these taxa's interactions with *S. halepense*. Complementing the community shifts, network analyses revealed differences in hub taxa and overall structure between biotypes despite maintaining similar community compositions. These network results suggest LI soils have stronger hub taxa associated with N_2-fixing taxa but differ in how these taxa interact between biotypes as infestation continues. However, regardless

of biotype present *S. halepense* biotypes curate similar bacterial composition, but maintain distinct structures that ultimately drive the same response. Overall, *S. halepense* influences its soil microbiome which in turn modifies performance and persistence. Overall, these results begin to understand the total contribution of the soil microbiome on a globally invasive weed.

120 - Leveraging Waterhemp (*Amaranthus tuberculatus*) Emergence Timing to Enhance Management in Soybean

Mercy Odemba[1], Mike Grimes[1], Kyle Ohanian[1], Eugene Law[1]

[1]The Ohio State University

Waterhemp (*Amaranthus tuberculatus* (Moq.)) has become a problematic and widespread herbicide resistant weed in Midwestern soybean production systems, with resistance documented to more than seven herbicide sites of action. Its rapid growth, high seed production, and extended emergence period contribute to persistent management challenges. Waterhemp competes with soybean for essential resources, resulting in significant yield losses and increased weed management costs. Understanding how waterhemp emergence timing and density influence soybean growth and competitive interactions could improve management strategies and reduce weed interference. This study investigated the effects of waterhemp emergence timing and density on soybean growth and biomass accumulation to identify opportunities for improving waterhemp management in soybean production. A greenhouse experiment evaluated two waterhemp emergence timings: waterhemp emerging two weeks before soybean and waterhemp emerging simultaneously with soybean. Waterhemp densities included 1,2,3, and 4 plants per pot, along with soybean and waterhemp monocultures. Soybean density was maintained at four plants per pot. Soybean biomass was evaluated to determine the effects of waterhemp emergence timing and density on crop performance. Preliminary results showed a significant (P=0.0173) interaction between waterhemp emergence timing and density on soybean biomass. Soybean biomass was greater when waterhemp emerged two weeks before soybean than when both species emerged simultaneously. However, at four waterhemp plants per pot, soybean biomass was greater under simultaneous emergence than when waterhemp emerged earlier. These results indicate that the effect of waterhemp emergence timing on soybean biomass depends on weed density, and soybean biomass did not consistently decline with increasing waterhemp density. This demonstrates that waterhemp emergence timing and density jointly influence soybean biomass, highlighting the complexity of crop weed competitive interactions. Therefore, incorporating waterhemp emergence timing and density into weed management strategies may improve control decisions and optimize integrated weed management programs

121 - Impact of Cropping-System Intensification on Germinable Weed Seedbanks Across U.S. Corn, Soybean, and Cotton Production Systems

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Understanding how long-term cropping-system management influences germinable weed seedbanks is critical for developing sustainable weed management strategies and reducing selection pressure for herbicide-resistant weed populations across diverse production environments. Long-term field trials were conducted at two locations [Scott (Mississippi) and Gothenburg (Nebraska)] using a split-plot design with three replications. Crop rotation served as the whole-plot factor [continuous corn vs. 2-year rotation (corn-soybean or corn-cotton) and 3-year rotation (corn-soybean-wheat)], while subplots combined tillage systems (strip vs. conventional or conventional vs. no-till) and cover crop regimes (cereal rye (*Secale cereale*) vs. no cover). Soil samples were collected in year 3 at 10-cm depth using five 10-cm diameter cores per plot. Soil samples were stored at 4°C, mixed 1:1 (v/v) with commercial substrate, and germinable seedbank fractions were quantified using greenhouse seedling emergence assays. Results varied across locations. At Scott, MS, Palmer amaranth (44.2%) and large crabgrass (43.4%) were the dominant species, together accounting for nearly 88% of all emerged seedlings. Significant tillage-by-cover crop interactions were detected for grass density ($P = 0.044$), broadleaf density ($P = 0.034$), Palmer amaranth density ($P = 0.028$), large crabgrass density ($P = 0.046$), and community composition. Under strip tillage, cereal rye reduced broadleaf emergence from 4,202 to 931 seedlings m^{-2} while increasing grass emergence from 573 to 3,127 seedlings m^{-2}. No significant cover crop effects were detected under conventional tillage. Under strip tillage, cereal rye substantially altered weed community composition, increasing grass and large crabgrass densities from 229 to 1,112 seedlings m^{-2} while reducing Palmer amaranth density from 1,604 to 74 seedlings m^{-2} (a 95% reduction). In contrast, under conventional tillage, weed functional-group densities were generally similar across cover crop treatments. At Gothenburg, NE, crop rotation was the primary driver of weed seedbank composition and abundance and significantly affected total weed ($P < 0.001$), grass ($P = 0.002$) and broadleaf ($P < 0.001$) density. Total germinable weed density increased from 18 seedlings m^{-2} under continuous corn (C) to 664 seedlings m^{-2} under the corn-soybean-wheat (CSW)rotations. Overall, weed seedbank responses were highly location-dependent, with crop rotation driving weed dynamics in Nebraska and crop rotation and cover crops shaping weed abundance and diversity in Mississippi. Future research should evaluate the impact of current practices on the weed seedbank five years after the implementation of the experiment.

Keywords: weed seedbank, crop rotation, cover crops, tillage, species richness, integrated weed management.

122 - Determining Emergence Periodicity of Major Agronomic Weeds in Ohio

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Agronomic weeds pose a significant threat to crop yields in Ohio due to competition and interference. The control of these weeds is a high priority for farmers, and the timing of management practices relative to the emergence windows of major weed species is essential for the efficacy of any weed control program. While previous research has established typical emergence periodicity for many agronomic

weeds in the Midwest, a localized data set would give more accurate information to growers in Ohio to inform their management practices. This study aims to provide more precise emergence periodicity data for eight common agronomic weeds in Ohio and the correlation between their emergence and environmental factors like precipitation and air temperature. To collect this data small plots were established on four research farms in 2026 in corn and soybean rotation systems and fallow areas. Data collection began at two locations in 2025 and has since expanded to encompass six site-years of emergence data. The emergence of eight species of interest (common waterhemp (*Amaranthus tuberculatus*), smooth pigweed (*Amaranthus hybridus*), Palmer amaranth (*Amaranthus palmeri*), velvetleaf (*Abutilon theophrasti*), giant ragweed (*Ambrosia trifida*), common lambsquarters (*Chenopodium album*), giant foxtail (*Setaria faberi*), yellow foxtail (*Setaria pumila*)) was observed and recorded weekly over a six-month period from March to August. The resulting data were analyzed to identify when emergence started, peaked, and ended for each species and revealed potential environmental influences. Data over more growing seasons and more locations will be necessary to present Ohio growers with more accurate and region-specific weed emergence windows.

123 - Investigating Control options for Field horsetail (*Equisetum arvense* L.).

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Scouring rush (*Equisetum hyemale* L.) is a seedless vascular perennial commonly infesting riparian areas. Populations are increasingly reported across the Midwest, and the architecture of plants (erect stems lacking leaves) renders control with typical POST herbicides difficult. A greenhouse study examined the response of scouring rush to POST herbicides commonly applied in IVM habitats. Plants were established for 4 months in 20 cm pots filled with a professional potting mix + sand. As plants reached 20-30 cm in height, 4 replicates were treated with imazapyr, glyphosate + imazapyr, or glyphosate alone with various surfactants (herbicide rates selected were appropriate for typical perennial species). In addition, indaziflam (residual) was applied as a split treatment with the second application timed 2 weeks later. At 14 days after treatment (DAT), imazapyr, glyphosate + imazapyr, and glyphosate + organosilicone surfactant resulted in >80% visual control. By 28 DAT, control with these three treatments ranged from 70-80%. Scouring rush response to indaziflam at 0.044 and 0.073 kg ai/ha was slow to develop, with 70 and 50% injury, respectively. However, at 28 DAT (14 days following the sequential application), injury for the respective treatments was 55 and 86%. Plant biomass at the 28 DAT timepoint was removed at the soil level and plants examined for regrowth. Four months after harvest, no regrowth occurred for the imazapyr, glyphosate + imazapyr, and the higher rate of indaziflam treatments. Control of scouring rush with imazapyr and glyphosate + imazapyr was not surprising. However, this is the first research showing that indaziflam controlled scouring rush following root absorption.

124 - Quantifying Response of Plant Communities to Landscape-Scale Farm Management Practices at Grace Drake Agricultural Laboratory (GDAL)

Kyle Ohanian[1], Mercy Odemba[1], Michael Grimes[1], Daniel Doretto[1], Eugene Law[1]

[1]The Ohio State University

Human activity, including agricultural practices, influences plant ecology and the conditions governing species distribution. While management practices can cause spatial variation in factors like crop performance and weed pressure, there is a persistent need to track how human activity affects the biodiversity of land under varying contexts of land management and evaluate emerging technologies that track plant biodiversity and field heterogeneity across diverse land management contexts. This ongoing project builds upon previous years’ monitoring efforts to implement long-term monitoring of plant biodiversity, emphasizing weed community composition, abundance, and spatial distribution, at the Grace Drake Agricultural Laboratory (GDAL) in Wooster, Ohio, by integrating and testing advanced spatial and vision-based technologies under realistic working farm conditions. The assessment compares plant communities under two landscape-scale farm management practices, a Standard Management Zone (simple rotations, synthetic fertilizers, vertical tillage) and an Agroecological Management Zone (complex rotations, organic fertility, minimal/no tillage with diverse cover crops). The levels of plant biodiversity are expected to fluctuate due to the reaction of plant species to the disruption caused by human activity. This year's research focuses on developing and validating plant mapping methods to evaluate the long-term viability of autonomous platforms and GIS tools in ecological monitoring. Specifically, we assess the feasibility of GIS-based mapping using camera systems and computer vision equipment integrated into autonomous crop scouting platforms (TerraClear / TerraScout) to automate plant detection, weed identification, and spatial distribution mapping across both management zones. To evaluate the long-term operational viability of these autonomous systems, field-verified mapping methods, including standardized line transects, are deployed alongside the autonomous platform to provide ground-truth comparisons. This work aims to determine the resolution, reliability, and practical application of autonomous plant and feature mapping at GDAL. The resulting integrated dataset will populate an interactive online GIS platform, supporting optimized integrated weed management strategies and advancing scalable precision technologies for Ohio farmlands.

125 - Emergence Pattern and Comparative Growth of Waterhemp and Palmer Amaranth Biotypes with or without Competition with Soybean

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Waterhemp (*Amaranthus tuberculatus*) is a problematic weed species in the Midwestern United States and has evolved resistance to multiple herbicide modes of action. Management efforts in this region have

largely focused on controlling waterhemp, potentially allowing other pigweed species, including Palmer amaranth (*Amaranthus palmeri*), to establish and spread. Although herbicide-resistant Palmer amaranth has been detected in Iowa, information on its emergence and growth under Iowa field conditions remains limited. Understanding these traits is essential for developing effective management strategies. Therefore, two field studies were conducted in Boone, Iowa, in 2026 to compare the emergence patterns and growth characteristics of both species with and without soybean competition. The studies were established in a reduced-tillage soybean field naturally infested with Palmer amaranth and waterhemp. Both experiments were arranged as randomized complete block designs with two treatments (with and without soybean competition) and four replications. In the first experiment, seedling emergence was monitored weekly from June to October using 32 permanent 0.25 m^2 quadrats (two per plot), with seedlings removed after counting. In the second experiment, growth characteristics of both pigweed species were evaluated using 64 individual plants (four plants per species per plot), with plant height measured repeatedly on the selected plants throughout the growing season. Cumulative emergence was modeled against day of year (DOY) and cumulative growing degree days (GDD) using a 3-parameter Weibull function. Plant height, total dry biomass, leaf area ratio, number of branches, and seed production were analyzed using linear mixed-effects models, with species, soybean competition as fixed effects and replication as a random effect. For plant height, individual plant nested within replication was included as a random effect to account for repeated measurements. Following soil tillage and soybean planting on May 29, 2026 (DOY 149), seedling emergence was observed within 7 d and monitored through October 9, 2026 (DOY 282). Waterhemp reached 50% cumulative emergence at 167.1 and 293.3 GDD (DOY 162 and 173) with and without soybean competition respectively. Palmer amaranth reached 50% emergence at 181.2 and 251.4 GDD (DOY 163 and 170), respectively. Both species recorded highest weekly emergence on June 12 (DOY 163). Without soybean competition, Palmer amaranth had a greater height increase per unit GDD (0.25 cm GDD^{-1}) than waterhemp (0.16 cm GDD^{-1}), with corresponding values of 0.50 and 0.30 cm GDD^{-1} under soybean competition. Palmer amaranth also produced greater aboveground dry biomass than waterhemp, averaging 323.7 and 179.7 g $plant^{-1}$, respectively, without soybean competition, compared with 234.2 and 159.8 g $plant^{-1}$ under competition. Seed production averaged 89,265 and 107,400 seeds $plant^{-1}$ for Palmer amaranth and 142,265 and 190,400 seeds $plant^{-1}$ for waterhemp under conditions with and without soybean competition, respectively. Under soybean competition, waterhemp reached 50% cumulative emergence earlier than Palmer amaranth. Regardless of soybean competition, Palmer amaranth produced more aboveground biomass, while waterhemp produced more seeds per plant. These findings highlight the threat both species pose to soybean production in Iowa and the importance of early-season weed management to reduce crop competition and prevent weed seedbank replenishment.

126 - Competitive Interactions Between Hemp (Cannabis sativa) Populations and Rotational Crops.

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Industrial hemp (*Cannabis sativa* L.) has gained attention as a rotational crop for fiber, grain, and industrial applications; however, limited information exists regarding its competitive behavior when volunteer or escaped hemp persists in subsequent crops. Escaped hemp may function as a weed,

interfering with crop growth and productivity. Additionally, differences among hemp genetic backgrounds may influence competitive outcomes. Therefore, a greenhouse replacement-series experiment evaluated competitive interactions between a commercial hemp cultivar (Yuma), a feral hemp population (Delavan), and four crop species: corn (*Zea mays* L.), soybean (*Glycine max* (L.) Merr.), milo (*Sorghum bicolor* (L.) Moench), and sunflower (*Helianthus annuus* L.). Four plants per pot were established at five hemp-to-crop proportions (0:4, 1:3, 2:2, 3:1, and 4:0), with four replications. Plant height, stem diameter, and leaf number were measured twice; flowering, survival, and aboveground biomass were assessed at termination. Competitive responses were quantified using hemp relative yield (HRY), crop relative yield (CRY), relative yield total (RYT), and aggressivity. Relative yield represents vegetative productivity compared with monoculture rather than grain yield. Data were analyzed using analysis of variance and mixed-effects models, with Tukey-adjusted comparisons. Hemp growth differed between genetic backgrounds. At the first measurement, plant height was similar between Yuma and Delavan (49.89 and 44.58 cm, respectively); however, by the second measurement, Yuma was taller (112.14 versus 90.23 cm). Yuma also produced thicker stems at both measurements (4.50 versus 2.99 mm and 7.40 versus 4.31 mm). Conversely, Delavan produced more leaves, increasing from 15.37 to 28.20 leaves plant^{-1} compared with 11.13 to 19.79 for Yuma. Delavan also had a greater probability of flowering (0.774 versus 0.464). These growth differences were reflected in hemp biomass. At the 1:3, 2:2, and 3:1 ratios, Yuma produced 15.63, 22.41, and 29.59 g pot^{-1}, respectively, compared with 5.31, 8.88, and 19.71 g pot^{-1} for Delavan. Under monoculture conditions, biomass was similar (40.63-41.30 g pot^{-1}). Crop biomass declined as hemp proportion increased. Yuma produced greater HRY than Delavan (0.558 versus 0.272), while CRY was lower in mixtures containing Yuma (0.493 versus 0.677), indicating greater crop suppression by Yuma. HRY increased from 0.256 at the 1:3 ratio to 0.608 at the 3:1 ratio, whereas CRY declined from 0.799 to 0.379. Overall RYT was 1.003 and did not differ from 1 ($P = 0.963$), indicating that increased hemp productivity generally offset reductions in crop productivity. Delavan exhibited negative mean aggressivity (−0.912), whereas Yuma was approximately neutral (0.123), indicating that Delavan was generally less competitive. Among crops, corn maintained the greatest CRY (0.670), followed by sunflower (0.603), milo (0.539), and soybean (0.528). Sunflower most strongly suppressed hemp (HRY = 0.292), whereas hemp performed best with milo (HRY = 0.501). Collectively, these results demonstrate that hemp competitive ability depends on genetic background and crop species, with Yuma exhibiting greater vegetative growth, biomass accumulation, and crop suppression than Delavan.

127 - Varietal Differences in Competitive Effects of Barley (*Hordeum vulgare*) on Palmer Amaranth (*Amaranthus palmeri*) Seedlings

Eduardo Lago[1], Karla Gage[1]

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Palmer amaranth (*Amaranthus palmeri* S. Watson) is one of the most troublesome weeds in the United States due to its competitiveness and herbicide resistance, causing severe yield losses in corn and soybeans. Integrating allelopathic crops such as barley into management systems could contribute to early season weed suppression following spring crop planting, but suppression is likely dependent upon environmental factors and barley cultivar characteristics. This study uses the plant-box method to evaluate the suppressive ability of living root exudates from five barley (*Hordeum vulgare* L.) cultivars: Pinnacle

(PIN), Robust (RBS), Secretariat (SECR), Sinergy (SNG), and Tradition (TDN) against Palmer amaranth seeding control, using cereal rye (*Secale cereale* L.) (CRYE) as a reference allelopathic cover crop and an unplanted control box. Donor plants were grown in the greenhouse for 7 days after emergence, transplanted into individual root zone-separating tubes and placed in GA-7 Magenta boxes filled with 0.3% agar + 1% sucrose solution. Thirty Palmer amaranth seeds were sown on the agar surface at specific distances, and boxes were incubated for 7 days at 24 °C and photoperiod of 14/10 h light/dark period. Roots and shoots of Palmer amaranth seedling were measured and plotted against the distance from the donor plant. Growth inhibition (GI) was calculated using the formula: [GI = 100 - (treatment intercept/control intercept) * 100]. Palmer amaranth shoot growth was reduced compared to the control by CRYE ($p < 0.01$) reducing shoot size by 67% ($R^2 = 0.25$) and by RBS ($p < 0.01$) reducing shoot size by 41% ($R^2 = 0.24$). Root growth was suppressed by CRYE ($p < 0.01$) reducing root to 54% ($R^2 = 0.31$) and three barley cultivars ($p < 0.01$): RBS reducing roots by 58% (R^2=0.20), TDN reducing roots by 54% (R^2=0.31), and PIN reducing roots by 45% (R^2=0.48). Cultivars of SECR and SNG showed no statistical difference compared to the control box. These findings suggest that barley can serve as a suppressive cover crop or preceding crop to help reduce Palmer amaranth pressure and therefore improve herbicide stewardship.

128 - Investigating Germination Ecology of Bosc's Mille Graines for Weed Management in Warm-Season Turfgrasses

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Bosc's mille graines (*Oldenlandia boscii*) is a perennial broadleaf weed in the Rubiaceae family, increasingly problematic in sod production fields of warm-season turfgrasses. Bosc's mille graines (BMG) forms prostrate, dense mats that negatively affect turfgrass aesthetics and sod quality. Germination responses of other problematic Rubiaceae weeds vary with environmental conditions, complicating management efforts in turfgrass systems. However, information regarding factors regulating BMG germination is lacking, further limiting the development of effective management strategies. Controlled environment experiments were conducted in 2025 and 2026 in Raleigh, NC to evaluate BMG germination and emergence responses to seed burial depth, soil moisture, air temperature, and light exposure to identify conditions favoring weed establishment. Three studies examined eight burial depths (0 to 10 cm), six soil moisture levels (10 to 100% field capacity), and three day/night temperature regimes under a 12-hour photoperiod or continuous darkness. Each experiment included six to eight replications and were repeated twice. BMG emergence declined exponentially with increasing burial depth (R^2 = 0.97), decreased to 51% at 0.5 cm and less than 5% at ≥1 cm, with no emergence from depths >4 cm. Soil moisture influenced BMG germination (R^2 = 0.99), with relative germination declining to 66%, 37%, and 17% at 80%, 60% and 40% field capacity, respectively, and no germination at ≤20% field capacity levels. Temperature and photoperiod interaction affected BMG germination. Under a 12-hour photoperiod, germination was 90% at 30/20 C and 57% at 25/10 C, whereas no germination occurred at 20/10 C with light or under continuous darkness. These findings provide a basis for predicting BMG emergence to assist practitioners with timing preemergence herbicide applications. Future research should investigate

seasonal BMG emergence patterns under field conditions and develop herbicide programs for weed management.

129 - Responses of 10 Common Weed Species to Waterlogging Duration

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A diverse assemblage of weed species threatens crop productivity across organic and conventional production systems in the Northeast and Midwest United States. At the same time, increasingly frequent and intense precipitation events are creating additional challenges for crop management. Effective weed control under these changing environmental conditions requires a better understanding of how prolonged soil saturation influences weed emergence. In this study, we evaluated the effects of waterlogging duration on the emergence of 10 economically important weed species. Two consecutive greenhouse experiments were conducted in which four replicates of each species were subjected to either waterlogged or non-waterlogged (control) conditions. Waterlogging treatments lasted for 1, 2, 3, 4, or 5 weeks, after which all treatments were returned to control conditions for the remainder of the experiment. Weed species exhibited a wide range of responses to waterlogging. Velvetleaf (*Abutilon theophrasti*) was highly sensitive, showing reduced emergence across all waterlogging durations. Palmer amaranth (*Amaranthus palmeri*) displayed moderate sensitivity, with emergence reduced by 30-50% relative to the control. In contrast, barnyardgrass exhibited a high tolerance to waterlogging, maintaining strong emergence across all treatments in both experiments. Species also differed significantly in their plasticity of response to waterlogging duration. Notably, common lambsquarters showed increased emergence relative to the control following the termination of the 3- and 4-week waterlogging treatments, suggesting a capacity for resilience through delayed emergence. These findings indicate that prolonged flooding and saturated soil conditions can suppress germination in several problematic weed species, while others remain capable of emerging and competing with crops, with responses strongly influenced by the duration of waterlogging.

130 - Agrivoltaic system effects on weed community composition and management vary in response to seasonal abiotic conditions

Dana Russell[1], Jinwook Kim[1], Caroline Marschner[1], Naomi Graseck[1], Scott Morris[1], Antonio DiTommaso[1]

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Agrivoltaic (AV) cropping systems offer a solution to land-use conflicts between renewable energy and crop production by enabling photovoltaic (PV) energy and crops to be produced on the same land. Shade from PV infrastructure reduces solar irradiance and increases relative humidity in AV systems compared with conventional cropping systems, creating a unique microclimate that alters crop growth. AV effects on weed communities and weed management efficacy, however, remain poorly understood. This study

evaluated the effects of an AV system on microclimate, weed density, biomass, community composition, and glyphosate efficacy in New York State in 2025 and 2026. We hypothesized that AV systems would 1) increase weed survival and growth in dry years, when water availability limits plant growth, but reduce survival and growth in wet years, when light availability is limiting, 2) alter community composition by favoring slower-growing, shade-tolerant species, and 3) improve weed suppression following glyphosate application due to combined canopy and solar panel shading. This study was conducted at two sites within a single axis tracking solar facility in New York State. Soybeans were grown under solar panels (AV treatment) and in an adjacent open field control with four replicate plots per treatment. Plots were split into weedy check (unmanaged) and glyphosate-treated subplots. Weed species counts were recorded immediately prior to glyphosate application and 3 and 7 weeks post-application, biomass was harvested at peak growth, and sensors monitored environmental conditions. Weed density and biomass were analyzed with generalized linear mixed models. Community composition was analyzed using permutational multivariate analysis of variance (PERMANOVA). Species responses to the AV treatment were tested using multivariate negative binomial generalized linear models. Growing-season precipitation was 35% below the 30-year average in 2025 and 26% above it in 2026. In the AV system, irradiance and vapor pressure deficit (VPD) were reduced by 25% and 12-13% relative to the control in both years. In weedy check subplots, average weed density was higher in the AV treatment 3.2x in 2025 and 4.1x in 2026. Weed biomass was 4.4x higher in the AV system in 2025 but did not differ between treatments in 2026. In both years, Virginia copperleaf (*Acalypha virginica*) and yellow woodsorrel (*Oxalis stricta*) were more prevalent in the AV system, and PERMANOVA results indicate that the weed community composition differed between AV and control treatments. In glyphosate-treated subplots, post-application weed density was 7.4-9.3x higher in the AV system in 2025 but did not differ between treatments in 2026, whereas weed biomass did not differ between treatments in 2025 but was 86% lower in the AV system in 2026. These results suggest that AV systems increase weed density regardless of seasonal moisture, but that their effect on weed growth relative to conventional systems depends on whether light or moisture is most limiting. In 2025, when lower VPD likely reduced moisture limitation under AV, unmanaged weeds accumulated more biomass than in the control, but combined canopy and PV panel shade offset this benefit after glyphosate application, so regrowth was similar. In 2026, when light was more limiting, PV shade restricted weed growth but not density, so higher AV weed density did not translate to higher biomass, and post-application regrowth was reduced. Furthermore, weed management in AV systems should target high early-season weed densities, include scouting for shifts in weed community composition, and, in dry years, assess weed survival and emergence after glyphosate application to determine whether follow-up control is needed.

131 - Macroevolutionary Patterns of Competition Response and Plasticity in Amaranthus

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Macroevolutionary Patterns of Competition Response and Plasticity in Amaranthus: A Greenhouse Study

132 - Emergence, Growth, and Reproduction of Waterhemp (*Amaranthus tuberculatus*) Populations from Six U.S. States under New York Conditions

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Waterhemp (*Amaranthus tuberculatus* L.) is one of the most troublesome pigweed species in the U.S. cropping systems and has recently invaded into the northeastern states, including New York. Its extended emergence, rapid growth, high seed production and resistance to multiple herbicides make it especially difficult to manage. However, limited information exists about how newly invaded waterhemp populations from other regions establish, grow and reproduce under New York's shorter growing season and cooler conditions. Two separate common garden field experiments were conducted at Cornell University in Ithaca, New York during summer of 2025 and 2026, to compare the emergence, growth and reproductive characteristics of waterhemp populations from six U.S. states: New York (NY), Connecticut (CT), Pennsylvania (PA), Nebraska (NE), Kansas (KS) and California (CA). Both studies were conducted in a randomized complete block design with five replications. For emergence study, about 100 seeds from each selected population were counted and sown on the surface of 20-L plastic pots (installed in the field) containing field soil. Seedling emergence was recorded every week from late May through late August. For the growth study, greenhouse-raised uniform seedlings of each population were individually transplanted into plastic pots containing field soil as previously described. Data on plant height, number of nodes, number of leaves, time to panicle initiation and panicle length were recorded on weekly intervals. In addition, the aboveground biomass of each waterhemp plant was recorded at full maturity and seed production from each female plant were determined. Results indicated that emergence of all waterhemp populations extended from mid-June through late August in both years. Total emergence differed among populations ($P = 0.017$): it was greatest for KS (21 plants plot^{-1}) and lowest for PA, NE and CA (7 plants plot^{-1}). Time to 50% emergence (T_{50}) ranged from mid-June (KS) to mid-July (PA). The PA population emerged 16 to 29 days later than the NY, CT, KS and VR populations, whereas time to 90% emergence did not differ among populations (late July to late August). In the growth study, the CA population had panicle initiation about four weeks earlier than the other populations and then stopped growing in height, reaching only 45 cm by early September. In contrast, plants from NY, NE and KS populations remained vegetatively longer, grew about twice as fast and reached 68 to 76 cm. Altogether, these results suggest that the origin of population can strongly influence the emergence, growth, and reproductive characteristics of waterhemp under New York conditions. These findings further reinforce the need for location-specific, integrated weed management strategies to limit the spread of waterhemp in the northeastern region.

133 - Abundance of Non-Structural Carbohydrate in Amaranthus spp. that Could Influence Weed Regrowth.

Anna R. Phillips[1], Jeffery J. Volenec[1], Mayara Rocha[1], Julie M. Young[1], Morgan E. Furze[1], Bryan G. Young[1]

[1]Purdue University

Abundance of Non-Structural Carbohydrates in *Amaranthus spp*. that Could Influence Weed Regrowth.

Anna R. Phillips, Jeffery J. Volenec, Mayara Rocha, Julie M. Young, Morgan E. Furze, Bryan G. Young.

Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus*) are two problematic C4 weed species common in the Midwest that are highly competitive even under stress conditions. Additionally, Palmer amaranth has an increased growth rate compared to waterhemp which contributes to challenges for management of the species. Non-structural carbohydrates (NSC) are primarily composed of soluble sugars and starch, and can be used to fuel respiration, plant regrowth, or as an energy buffer during stress periods. These carbohydrate reserves exhibit diurnal fluctuations in some species based on the plant photosynthetic cycle. The increased growth rate of Palmer amaranth indicates that there may be potential differences in reserve carbohydrate concentrations between the two *Amaranthus* species. Our objectives were to determine if the concentration of starch and sugar reserves fluctuates between these species and diurnally within or across the species. The experiment was conducted as a randomized complete block design with four replications, conducted once. Palmer amaranth and waterhemp plants were sampled at the 12 and 10 leaf stages, respectively (10 to 15 cm in height). Plant tissue sampling occurred in two events: one before 10:00 AM and the other after 7:00 PM. Fifteen plants per species were pooled into a sample after being dissected by tissue type (mature leaves, young leaves, petiole, stem, and root). Samples were frozen at -80°C, lyophilized, and ground to prepare for extraction. Soluble sugar concentrations were determined using an 80% ethanol extraction before an anthrone colorimetric assay was used to determine the absorbance of each sample. Once soluble sugars were removed, the sample pellet was dried, and an enzyme solution was used to degrade starch molecules into glucose. An aliquot of the degraded starch solution was used in a glucose TRINDER assay to determine the absorbance. A standard curve and the original sample weight were used to determine glucose and starch content [% dry weight (DW)]. These sugar and starch concentrations were summed to yield a total non-structural carbohydrate concentration (TNC). Total TNC concentrations in Palmer amaranth stems are up to two times greater than that of waterhemp. Evening TNC concentrations of both species exhibit a two-fold increase in leaf tissues when compared to morning concentrations. These findings demonstrate tissue specific diurnal TNC fluctuations in both species, as well as species differences within leaf tissue that could function to support plant regrowth following foliar herbicide applications.

134 - Shattercane (*Sorghum bicolor* ssp. *drummondii*) Emergence Patterns and Their Relevance to Infestations in Corn

Lidia K. Myers[1], Caden O'Connor[1], George Oganda[1], Reid J. Smeda[1]

[1]University of Missouri

The extended emergence period of shattercane (*Sorghum bicolor* subsp. *drummondii*) presents challenges for effective weed management in corn (*Zea mays* L.). Understanding when seedlings emerge and how emergence patterns vary across locations and growing seasons is important for predicting the establishment of shattercane infestations. Field studies were conducted during 2025 and 2026 at two sites with endemic shattercane populations in central Missouri to characterize seasonal emergence patterns. Five 0.25-m² quadrats were established at each location in May, with emerged seedlings counted and removed weekly throughout the growing season. Soil temperature and moisture data were collected to examine environmental conditions associated with emergence. Peak weekly emergence occurred in June at both locations in both years, with 50% of cumulative emergence occurring between mid-June and early July. However, emergence continued over much of the growing season, spanning 119 and 112 days at each location in 2025. Although the timing of peak emergence was relatively consistent, emergence density and the distribution of seedlings throughout the season varied between locations and years. These findings suggest that while a substantial portion of shattercane emergence occurs early in the growing season, continued seedling recruitment extends beyond the period where POST herbicides are applied in corn. Future studies should consider targeting late emerging shattercane to preclude building soil seedbank populations.

135 - Goosegrass (*Eleusine indica*) Emergence Patterns and Fecundity

Caden O'Connor[1], Reid J. Smeda[1], Lidia K Myers[1], George Oganda[1]

[1]University of Missouri

Goosegrass (*Eleusine indica* L.) is a C4 annual grass that thrives in warm climates, consistently ranking among the most problematic weeds in global agriculture. While not historically seen as a problematic weed in Missouri row crop systems, the frequency of observing goosegrass has increased. To determine seasonal emergence patterns along with vegetative vigor and fecundity, research was conducted in the 2025 and 2026 growing seasons at 2 locations in central Missouri. To determine emergence patterns, six 0.25 m^2 square quadrants were randomly established at each location. For 2025, 400 viable seeds of goosegrass were evenly distributed across the quadrants to simulate a natural population while 2026 locations utilized an endemic population. Emergence peaked in mid-June at each location across both years, while 2026 saw a slightly longer emergence window from May 8th through August 21st. To assess fecundity and vegetative vigor, goosegrass seedlings were established from seed in greenhouse conditions prior to being transplanted into rows at each field location monthly from May through September in both years. September seedlings failed to establish across either location in both years. Plants were thinned after establishment to reduce competition until six plants were left for each month’s plantings. Throughout the growing season, seedheads were collected as they reached maturity to avoid loss from shattering. Upon senescence, above-ground plant biomass was collected to quantify biomass weight, tillering, and seed production. Across locations and years, goosegrass plants established in May and June produced greater amounts of biomass, tillers, and seed compared to plants established in July and August, with singular May established plants producing over 100 tillers and up to 140,000 seeds. While not as prolific as earlier established goosegrass, July and August established plants produced over 9,000 seeds on average across locations. Results suggest that the extended emergence window of goosegrass allows

plants to become established beyond POST herbicide timings in agronomic crops. The prolificness of plants will allow soil seedbank populations to build. Future studies should focus on the ability of goosegrass seedlings to grow in established stands of corn and soybean.

Student Poster Contest – Weed Genetics and Herbicide Physiology

136 - Emerging Johnsongrass Infestations in Wisconsin: Monitoring for Herbicide Resistance

Antonio de Lucena[1], Ahmadreza Mobli[1], Sabeel Abuhakmeh[1], Josh Kamps[1], Daniel Smith[1], Rodrigo Werle[1]

[1]University of Wisconsin-Madison

Johnsongrass [*Sorghum halepense* (L.) Pers.] is being increasingly detected in corn and soybean fields across southern Wisconsin, raising concerns about its potential adaptation and establishment as a new problematic weed in the state. Resistance to acetolactate synthase (ALS)-inhibiting herbicides has been documented in johnsongrass populations in Nebraska and Kansas, and resistance to acetyl-CoA carboxylase (ACCase) inhibitors and glyphosate (5-enolpyruvylshikimate-3-phosphate synthase inhibitor) has been reported in southern U.S. states such as Texas, Mississippi, Tennessee, Louisiana, Virginia and Kentucky, raising concerns about the potential introduction and presence of herbicide-resistant johnsongrass populations in Wisconsin. The objectives of this study were (1) to evaluate resistance in Wisconsin johnsongrass accessions to commonly used postemergence (POST) herbicides: clethodim and quizalofop-P-ethyl (ACCase inhibitors), nicosulfuron and imazethapyr (ALS inhibitors), and glyphosate, and (2) to compare how glufosinate (glutamine synthetase inhibitor), tembotrione and topramezone (4-hydroxyphenylpyruvate dioxygenase inhibitors), and the herbicides listed in objective (1) applied at field rate perform on johnsongrass. Seed from nine accessions collected from field margins across southern Wisconsin in the fall of 2025, were evaluated under controlled environment greenhouse conditions. Each herbicide listed under objective (1) was applied at 0.5×, 1×, and 3× the recommended field-use rate. The additional herbicides related to objective (2) were applied at the 1× recommended field-use rate. The experiment was conducted as a completely randomized design with six replications and repeated over time (two experimental runs). Each experimental unit consisted of one plant grown in a 656-mL Cone-tainer. Herbicides were applied when plants reached 10 cm in height using a single-nozzle spray chamber calibrated to deliver 140 L ha^{-1}. Plant survival was visually assessed at 21 days after treatment (dead vs. alive), and accessions exhibiting at least 50% plant survival for a given herbicide and application rate were classified as resistant to the respective treatment combination; otherwise, classified as susceptible. Biomass reduction relative to the nontreated control was also determined. All accessions were classified as susceptible to clethodim, quizalofop-P-ethyl, and glyphosate at all rates tested. In contrast, three accessions were classified as resistant to imazethapyr at the 0.5× rate, and one of them classified as resistant to the 1× and 3× rates; this accession was also classified as resistant to nicosulfuron at 0.5× rate. At the 1× recommended field-use rate, biomass reduction across accessions was at least 97% for clethodim, quizalofop-P-ethyl, glyphosate, glufosinate, and nicosulfuron, 96% for imazethapyr, 93% for

tembotrione, and 10% for topramezone. These findings indicated that Wisconsin johnsongrass accessions are largely susceptible to commonly used POST herbicides, but identified potential imazethapyr resistance in one accession, emphasizing the importance of continued resistance monitoring and effective herbicide selection. Further research is needed to investigate local ecological adaptation, confirm herbicide resistance, identify the underlying herbicide resistance mechanisms, and determine whether herbicide-resistant acessions are being introduced from other states or evolving locally.

137 - Unraveling Vernalization Responses in Spring and Winter Annual Italian Ryegrass (*Lolium perenne* ssp. *multiflorum*) Using RNA Sequencing

Disha Ande[1], Samuel Revolinski[1], Travis Legleiter[1]

[1]University of Kentucky

Italian ryegrass (*Lolium perenne* ssp. *multiflorum*) is a troublesome winter annual weed in row-crop production systems across the southeastern United States, where resistance to glyphosate, acetolactate synthase (ALS) inhibitors, and acetyl-CoA carboxylase (ACCase) inhibitors, prolonged emergence and prolific seed production complicates management. Differences in flowering responses to winter temperatures may further influence reproductive development and the timing of chemical management interventions. Vernalization, the promotion of flowering through prolonged exposure to low temperatures, is an important mechanism regulating seasonal development in temperate grasses such as winter-wheat. However, the molecular mechanisms underlying variation in vernalization responses among Italian ryegrass populations remain poorly understood. This study investigated transcriptional responses to cold exposure in four Italian ryegrass populations: Mint (Mt) and Stranton (St) from Kentucky, and Garfield (Gf) and Whitman (Wt) from Washington. The Washington populations are known spring annuals and were included in the study to compare responses among populations with contrasting seasonal growth patterns. Plants were maintained under vernalized and non-vernalized conditions, with leaf tissue collected before vernalization (T0), during vernalization (T1; 21 days of cold exposure), and after vernalization (T2; 14 days following completion of 28 days of cold exposure). RNA sequencing and DESeq2 analysis were used to identify differentially expressed genes (DEGs; at adjusted $p < 0.05$). Comparisons of gene expression across all corresponding timepoints and treatments revealed a distinct pattern for the flowering repressor *VRN2,* with higher expression observed primarily in Mt, particularly under non-vernalized conditions. In temperate grasses, *VRN2* is associated with the repression of flowering, suggesting that its expression in Mt may contribute to a winter annual growth habit by repressing *VRN1*(flowering gene) before sufficient cold exposure. Consistent with this interpretation, a comparison between vernalized (V) and non-vernalized (N) Mt plants at T1V and T2V showed significantly higher expression of *VRN1* following vernalization (log_2 fold change = 5.46; adjusted $p = 2.25 \times 10^{-7}$). In contrast, *VRN1* did not exhibit significant vernalization associated differences in St, Gf, or Wt at T1 or T2. Together, these findings indicate that differences in the regulation of *VRN2* and *VRN1* may contribute to variation in flowering responses among Italian ryegrass populations. Therefore, understanding how winter temperature influences reproductive development could ultimately help refine population-specific management strategies aimed at preventing seed production and reducing seedbank replenishment.

138 - Advancing Computer Vision Pipelines for High-Throughput Weed Phenotyping

Jason Yang[1], Lalit Magar[1], Alyssa Essman[1], Ram Yadav[1], Hari Subramoni[1], Eugene Law[1]

[1]The Ohio State University

This project investigates whether computer vision can automatically quantify herbicide injury and distinguish herbicide-specific symptomology in weeds from RGB imagery. By providing a rapid, objective, and non-destructive approach to plant phenotyping, this work aims to support scalable weed management research and accelerate both basic and applied agricultural studies.

139 - Computer Vision-based Herbicide Resistance Screening in Waterhemp (*Amaranthus tuberculatus*)

Lalit Pun Magar[1], Jason Yang[2], Daniel Doretto[1], Matthew Thompson[3], Alyssa Essman[1], Ram Yadav[1], Sami Khanal[4], Hari Subramoni[2], Eugene Law[1]

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Multiple herbicide-resistant waterhemp (*Amaranthus tuberculatus*) has rendered many common herbicide chemistries ineffective in Ohio corn and soybean. Confirmation of resistance relies on greenhouse-based dose response assays upon the putative resistant populations. Evaluating herbicide efficacy is currently carried out by experienced weed researchers using methods which are time consuming, labor intensive, and prone to subjectivity. Therefore, there is a need to streamline current methods of understanding the response of treated and untreated plants and provide objective results. Computer vision can extract important features from images of plants, including changes in plant structures and growth. Vision foundation models produce general purpose image embedding and allow accurate classifiers to be trained on small datasets without need of retraining. We evaluated whether such embedding with foundation models can objectively classify waterhemp damage symptoms. Waterhemp populations with suspected postemergence herbicide resistance were grown under greenhouse conditions until they reach 10 cm. These plants were treated with four herbicides (glyphosate, glufosinate, 2,4-D, and Fomesafen) at 0.5x, 1x, and 3x the labeled rate. Using PlantMap3D, 78 pots were imaged one day before treatment to gather baseline images and at 3, 5, 7, 14, and 21 days after treatment (DAT) making 622 total images. Images were annotated as healthy, or exhibiting cholorosis, necrosis, epinasty, or foliar distortion by a rater. During image analysis, each image was represented as full frame, cropped, and segmented, and embedded with four frozen models (BioCLIP, BioCLIP2, BioCLIP2.5, and DINOv3 Vit-7b/16). Three image representations crossed with four models gave 12 model-representation combinations. Linear classifiers were trained on each embedding set and evaluated on five-fold cross-validation grouped by pot, so that all images of a plant remained in the same fold. Across combinations, F-scores increased with training image

size and remained consistent at 0.85-0.90 at 40-60 images per class. The original BioCLIP outperformed other sophisticated models, particularly on full-frame images (F1=0.9). Binary classifiers comparing each symptom against untreated controls produced the same ranking except epinasty where DINOv3 was superior. Chlorosis and necrosis were detected consistently while foliar distortion (F1 = 0.65) was least detected, most probably due to the least number of images representing this class. These results show that frozen, biology-specific embeddings can support objective herbicide injury classification and provide a step toward automated scoring of resistance screening assays.

140 - Screening for Herbicide Resistance in Kochia (*Bassia scoparia*) Populations from South Dakota

FNU Muskan[1], Matthew Vredenburg[1], Eric Jones[1], Sachin Dhanda[1]

[1]South Dakota State University

Multiple herbicide-resistant kochia [*Bassia scoparia* (L.) A. J. Scott] populations pose a serious threat to crop productivity across the Great Plains. Although resistance to glyphosate and acetolactate synthase (ALS) inhibitors is widespread, information regarding herbicide-resistant kochia populations in South Dakota remains limited. The objective of this study was to evaluate South Dakota kochia populations for resistance to commonly used herbicides representing multiple sites of action. Eleven kochia populations were collected from nine South Dakota counties in 2025 and grown under greenhouse conditions at South Dakota State University. Populations were screened with nine herbicides representing seven sites of action: Group 2 (imazamox), Group 4 (dicamba, fluroxypyr, and halauxifen + fluroxypyr), Group 5 (atrazine), Group 6 (bromoxynil), Group 9 (glyphosate), Group 10 (glufosinate), and Group 14 (saflufenacil). Herbicides were applied at labeled rates in a closed spray chamber when plants reached 7 to 10 cm in height. Plant survival was recorded 21 days after treatment. Populations were classified as susceptible (<2% survival), moderately resistant (2-19%), or resistant (≥20%). The experiment was arranged in a completely randomized design, with 50 seedlings per population × herbicide treatment combination grown in 50-cell trays and repeated as two independent experimental runs. Significant differences in survival were observed among populations and herbicides ($P < 0.001$), with a significant population × herbicide interaction ($P = 0.015$). All screened populations showed resistance to Group 2, and 9 populations were resistant to Group 9. Multiple resistance was observed with three populations showing resistance to five sites of action (Groups 2, 4, 5, 9, and 14), two populations to four sites of action (Groups 2, 4, 5, and 9), and four populations to three sites of action (Groups 2, 5, and 9). Although bromoxynil (Group 6) and glufosinate (Group 10) provided effective control of most evaluated populations, resistance to multiple herbicide sites of action highlights the need for diversified chemical and nonchemical weed management strategies. Future dose-response studies will quantify resistance in selected populations to the respective herbicide group(s).

141 - Pooled amplicon sequencing for the simultaneous detection of multiple target-site resistance mechanisms

Yeong Shin[1], Sara Alvarez Rodriguez[1], Michael Ozolins[1], Eric Patterson[1]

[1]Michigan State University

Herbicide resistance threatens sustainable chemical weed control, making the rapid and accurate diagnosis of resistance essential for managing its evolution and spread. While target-site resistance (TSR) molecular assays offer substantial improvements in speed over greenhouse-based diagnostics, conventional workflows rely on independently amplifying and sequencing individual genes. This locus-by-locus approach remains laborious and expensive, especially when screening large populations across multiple herbicide modes of action. To increase throughput and cost-effectiveness, we are developing a multiplexed amplicon sequencing strategy for *Amaranthus palmeri*. We designed an amplicon panel covering the known resistance-conferring mutations in *ALS*, *EPSPS*, and *PPX2*, the target-site genes of three major herbicide modes of action (ALS inhibitors, glyphosate, and PPO inhibitors), so that all targets from a single plant are amplified and sequenced together in a single reaction. Multiplexed amplicons were sequenced with long-read Oxford Nanopore technology and reads were aligned to reference sequences and processed through an automated variant-calling and annotation pipeline. Pooled amplicon sequencing reads generated from this assay were aligned to reference sequences using HiSat2, followed by automated variant calling with GATK. Preliminary results show that multiple resistance-associated loci can be simultaneously amplified, sequenced, and genotyped from the same individual. By replacing separate gene-specific PCR and sequencing reactions with a single multiplexed assay, this approach reduces per-sample diagnostic costs and labor. Ongoing and future work focuses on pooling DNA from multiple individuals and on expanding the panel to additional weed species and herbicide target sites. Overall, this study establishes a robust, cost-effective framework for multi-gene TSR screening in *A. palmeri*, laying the technical foundation for the Comprehensive Array for Target Site resistance detection (CATS), a high-throughput targeted genotyping-by-sequencing platform that will support comprehensive resistance epidemiology and timely weed management recommendations.

142 - Quantifying the Biochemical Interactions Between HPPD- and PSII-Inhibitors

Abigail N. Norsworthy[1], Grant D. Isaacs[1], Joshua R. Widhalm[1], Thomas R. Butts[1], Bryan G. Young[1]

[1]Purdue University

Effective management of waterhemp (*Amaranthus tuberculatus*) is a major challenge in corn (*Zea mays*) production systems, making herbicide tank-mixtures a necessity rather than a luxury. Combining hydroxyphenylpyruvate dioxygenase (HPPD)-inhibiting herbicides and photosystem II (PSII)-inhibiting herbicides is a common practice that can improve overall herbicide efficacy, with documented synergy between these two sites of action. However, the biochemical basis for the synergy between HPPD- and PSII-inhibitors has remained more theoretical than certain. Some research groups have proposed that combining the two herbicide groups provides a competitive advantage because HPPD-inhibitors deplete

plastoquinone (PQ) while PSII-inhibitors compete with the already limited PQ at the D1 binding site. To explore this interaction further, laboratory research was conducted to determine: 1) PQ concentration in waterhemp treated with HPPD- and PSII-inhibitors alone and in combination, and 2) whether synergy could be observed in the form of lower PQ concentrations. In a time-course experiment (0, 2, 4, 8, and 12 hours after application (HAA)), waterhemp PQ concentrations decreased by 50% at 5, 6, and 8 HAA for pyridate, atrazine, and mesotrione, respectively. A subsequent herbicide interaction experiment was conducted between these two PSII-inhibitors and mesotrione at 6 HAA since PQ concentrations were reduced by approximately 50% for all three herbicides when applied alone. Depending on the herbicide, the combination of pyridate or atrazine with mesotrione lowered PQ levels by an additional 10 to 21%. However, Colby's analysis of PQ concentrations determined the interaction for atrazine plus mesotrione was additive, while pyridate plus mesotrione elicited an antagonistic interaction. This classification of the herbicide interactions can be misleading, as both herbicide combinations resulted in lower PQ concentrations that would compete with atrazine at the D1 binding site. Thus, extending the use of Colby’s analysis to biochemical interactions may be inappropriate and too far removed from the intended use for whole activity on target plants. Furthermore, use of the alternative isobole method to characterize this biochemical interaction would be problematic due to the extensive number of treatments and biochemical analyses that would be required. Overall, the depletion of PQ for substrate competition with PSII-inhibiting herbicides may not fully explain the whole-plant synergy for these herbicide site-of-action groups. Nevertheless, this biochemical method of PQ quantification may prove valuable to further investigate interactions between PSII-inhibitors and other carotenoid biosynthesis inhibitors.

143 - Developing Hydroponic Screening Methods to Characterize Crop Sensitivity to Soil-Applied Herbicides

Emma J. Lagerhausen[1], Julie M. Young[1], Bryan G. Young[1]

[1]Purdue University

Preemergence herbicides provide great utility in weed management programs, by reducing weed interference during critical crop growth stages and delaying the timing of postemergence applications during a growing season. However, a genotypic response in injury expression has been documented in several crops to soil-applied herbicides. Molecular markers and field assays can be used to screen crops for herbicide sensitivity, but few functional molecular markers are available and field conditions may not allow a discriminating response to be observed in some years due to inconsistent environmental conditions. Conversely, a hydroponic assay removes environmental variability and can be used to rapidly screen crop genotypes for sensitivity to soil-applied herbicides. Corn (*Zea mays*) exhibits hybrid sensitivity to amicarbazone and metribuzin, photosystem II (PSII)-inhibiting herbicides, and soybean (*Glycine max* (L.) Merr.) exhibits varietal sensitivity to saflufenacil, a protoporphyrinogen oxidase (PPO)-inhibiting herbicide. Therefore, the objectives of this study were to 1) characterize injury from amicarbazone and metribuzin in corn and saflufenacil in soybean to identify the most effective form of data collection to identify a genotypic difference in herbicide response, and 2) establish a discriminating dose of each herbicide to screen germplasm. Two corn hybrids were exposed to amicarbazone or metribuzin (0, 25, 100, 400, 1600, 4800, and 6400 ppb), and six soybean cultivars were exposed to saflufenacil (0, 40, 80, or 120 ppb) in a hydroponic assay. These crop seed lines were selected based on

previous assays of herbicide sensitivity. Corn and soybean roots were digitized with a flatbed scanner and processed in Rhizovision Explorer to calculate length, diameter, and area. Corn leaves were scanned and processed in Turfanalyzer to calculate the percent reduction in green leaf tissue. Visual estimates of injury to corn roots and shoots were made on a scale of 0 to 100. Corn and soybean roots and shoots were collected for dry weight measurements. Data were converted to percent reduction of the nontreated control, the response of the putative tolerant and sensitive germplasm were compared using Welch's t-test (α= 0.05). A distinguishing response between corn hybrids to amicarbazone and metribuzin was observed on leaf tissue, and a discriminating dose of 6400 ppb to either herbicide was established. However, a distinguishing response between soybean cultivars to saflufenacil was observed on root tissue, and a discriminating dose of 80 ppb was established. These methods can be used to screen crop species for a genotypic response to soil-applied herbicides, either independent of or in addition to other methods of sensitivity screening.

144 - Inheritance of Glufosinate-Ammonium Resistance in a Waterhemp (*Amaranthus tuberculatus*) Population from Illinois

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Waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] is a dioecious summer annual weed and one of the most troublesome weeds in the midwestern United States. This species has evolved resistance to herbicides spanning eight sites of action (SOAs), including the recently reported resistance to glufosinate-ammonium (SOA Group 10). The Illinois waterhemp population FRA has evolved resistance to glufosinate-ammonium, with enhanced herbicide metabolism considered as the most likely resistance mechanism. Understanding the inheritance of this resistance is important for developing better resistance management strategies. Therefore, the objective of this study was to investigate the inheritance of glufosinate-ammonium resistance in FRA. Reciprocal crosses between resistant (R) and susceptible (S) populations were carried out to obtain F_1 lines, designated $F_{1\text{-}1}$, $F_{1\text{-}2}$, $F_{1\text{-}3}$, and $F_{1\text{-}4}$. A whole plant dose-response study was conducted in the greenhouse in a completely randomized design with six waterhemp populations (R, S, $F_{1\text{-}1}$, $F_{1\text{-}2}$, $F_{1\text{-}3}$, and $F_{1\text{-}4}$) and four glufosinate-ammonium rates 0, 164, 245, 327 g ai ha^{-1}. Each treatment had 10 to 33 replications and was repeated once over time. The number of replications varied due to seed availability and germination limitations. The seeds of each population were initially planted in flats and individual seedlings with the first true leaves were transplanted into individual cones. The herbicide treatments were applied once plants reached 7.5 to 10 cm in height using a spray chamber equipped with an 80015 EVS nozzle, calibrated to deliver 140 L ha^{-1} at 207 kPa. All treatments included ammonium sulfate at 2.5% of the application volume. At 21 days after application, survival and aboveground biomass were collected, biomass was harvested separately for each plant, oven-dried and weighed. The biomass and survival data for the F_1 populations showed herbicide sensitivity intermediate to that of parental populations, demonstrating genetic inheritance of glufosinate resistance. Further experiments incorporating additional herbicide rates are needed to better characterize the dose response relationships and clarify the inheritance of the resistant trait. Future research will evaluate resistance segregation in F_2 and backcross populations.

145 - Confirmation and Characterization of Paraquat-Resistant Horseweed (*Erigeron canadensis*) in New Jersey Highbush Blueberry**

Carrie Mansue[1], Beth Ferguson[1], Caio Brunharo[2], Adrian Veron[2], Lynn Sosnoskie[3], Thierry Besancon[1]

[1]Rutgers University, [2]Penn State University, [3]Cornell AgriTech

Horseweed (*Erigeron canadensis* L.) poses a management challenge in grapes, apples, and berries across the eastern and north-central United States, as well as in agronomic crops. Resistance to multiple herbicide sites of action and long-distance wind dispersal complicate management, with paraquat resistance documented in California, Mississippi, Delaware, and New York. Reports of reduced paraquat efficacy in New Jersey blueberry fields prompted greenhouse dose-response assays in 2025 at the Philip E. Marucci Center for Blueberry and Cranberry Research in Chatsworth, NJ. Three New Jersey biotypes collected from commercial blueberry fields in Hammonton (NJ-ST and NJ-WH) and a soybean-corn rotation field in Bridgeton (NJ-RA) were compared with two confirmed paraquat-resistant New York biotypes from a vineyard (NY-GR) and an apple orchard (NY-AP), and a susceptible roadside biotype (NY-RO). Biotypes and paraquat rates were arranged factorially in a completely randomized design, with rates ranging from 17.5 to 8,960 g ai ha^{-1}. Fresh biomass, visual control, and mortality were assessed at 21 days after treatment. At the blueberry label rate (1,120 g ai ha^{-1}), NJ-ST retained approximately 20% of untreated fresh biomass, yet 46% of plants survived, compared with 0% of NJ-WH and 4% of NJ-RA plants. At the highest tested rate (8,960 g ai ha^{-1}), NJ-ST biomass declined to approximately 11%, but survival remained 46%, compared with 4% for NJ-WH and 0% for NJ-RA and NY-RO. Surviving NJ-ST plants continued to grow, with approximately 60% visual control at this rate. The estimated rate required to reduce fresh biomass by 90% (GR_{90}) was 16,594 g ai ha^{-1} for NJ-ST, approximately 60-fold greater than NJ-WH (275 g ai ha^{-1}) and NJ-RA (271 g ai ha^{-1}), although the NJ-ST estimate required extrapolation beyond the tested range. NJ-ST survival at the highest rate was lower than that of the confirmed resistant NY-GR and NY-AP biotypes, which exhibited 79% and 67% survival, respectively. Together, these findings demonstrate that substantial biomass suppression did not translate into complete mortality in NJ-ST. Its elevated GR_{90} estimate and continued survival and growth at high rates distinguish NJ-ST from NJ-WH and NJ-RA and support putative paraquat resistance. Further research will characterize this response and investigate the underlying mechanisms.

146 - Mechanisms of Auxinic Herbicide Resistance in Waterhemp (*Amaranthus tuberculatus*)

Adebisi Adeleke[1], George Walker[1], Jerry Cohen[1], Michael Ozolins[2], Eric Patterson[2], Navjot Singh[1], Tom Peters[1], Debalin Sarangi[1]

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Waterhemp (*Amaranthus tuberculatus*) is a major weed threatening soybean production in the Midwestern United States. The evolution of resistance to multiple herbicide sites of action (SOA) has further complicated its management. Recently, two waterhemp populations from Lincoln (LNK) and Lyon (LYN) Counties, Minnesota, were confirmed resistant to herbicides from six different SOA, including the auxin mimics (2,4-D and dicamba). Although these herbicides share the same SOA, whether resistance to both is mediated by a shared mechanism or distinct mechanisms remains unclear. The objective of this study was to investigate the mechanisms underlying resistance to 2,4-D and dicamba in these populations. Greenhouse experiments were conducted to evaluate cross-resistance between 2,4-D and dicamba by treating clones derived from plants that survived either herbicide with the other herbicide. Also, experiments were conducted to assess the potential involvement of cytochrome P450-mediated metabolism using malathion pretreatment followed by 2,4-D or dicamba at 1x and 2x labeled rates (1,063 and 560 g ae ha^{-1}, respectively). Liquid chromatography-tandem mass spectrometry (LC-MS/MS) was used to compare the relative abundances of dicamba and its metabolite and examine changes in parent 2,4-D signals over time between resistant and susceptible populations. Among clones derived from 2,4-D survivors, 54% survived dicamba, whereas 36% of clones derived from dicamba survivors survived 2,4-D treatment, indicating partial cross resistance between the two herbicides. Malathion pre-treatment resulted in variable survival responses across populations and herbicides. At labeled dose of dicamba application, percent survival following the higher malathion rate was lower in both resistant populations, decreasing from approximately 40% to 29% in LNK and from 67% to 38% in LYN, whereas responses were inconsistent at the 2x dicamba rate. In 2,4-D treatments, malathion effects were inconsistent across populations and herbicide rates. These responses provided inconclusive evidence for cytochrome P450 involvement in auxin resistance. LC-MS/MS analysis showed significantly higher relative abundances of parent dicamba and 5OH-dicamba in the resistant population than in the susceptible population, whereas known metabolites, 3,6-dichloro-2-hydroxybenzoic acid and 2-chloro-6-hydroxybenzoic acid did not differ significantly. Greater parent dicamba abundance suggests that enhanced metabolism may not fully explain resistance, raising the possibility of altered auxin perception or signaling. For 2,4-D, preliminary isotope dilution analysis showed an increasing unlabeled-to-labeled 2,4-D signal ratio over time in resistant plants but a decreasing ratio in susceptible plants, suggesting differences in apparent disappearance of parent 2,4-D. These findings suggest that enhanced herbicide metabolism alone may not fully explain resistance to 2,4-D and dicamba. Further research will investigate potential target-site resistance mechanisms and dicamba conjugation pathways to better understand resistance in these waterhemp populations.

147 - Environmental Impacts on 2,4-D Metabolism and Efficacy Across Diverse Midwestern Waterhemp (*Amarantus tuberculatus*) Populations

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For Midwestern growers, waterhemp (*Amaranthus tuberculatus*) is more than just a competitive weed. It is an increasingly difficult management challenge in soybean production systems. As a dioecious species

and prolific seed producer, waterhemp exhibits high levels of genetic diversity, allowing resistance to evolve rapidly across multiple herbicide sites of action. This genetic variability has led to both target-site resistance (TSR) and non-target-site resistance (NTSR) mechanisms throughout the Midwest. Current research suggests that the predominant resistance mechanism in waterhemp is due to enhanced metabolism. The objective of this research was to evaluate the impact of temperature variations on 2,4-D metabolism in both resistant and susceptible populations. Specifically, we evaluated how heat stress affects 2,4-D efficacy, by quantifying temperature and herbicide injury interactions through biomass, survival and metabolite concentration experiments, to assess whether drought stress alters resistance levels. Experiments were conducted using three waterhemp populations: two confirmed 2,4-D-resistant populations, one from Nebraska and one from Michigan, and a susceptible reference population from Illinois. Results demonstrated that heat stress significantly reduced 2,4-D efficacy in resistant biotypes resulting in increased metabolite concentrations, together with higher biomass and greater plant survival. These findings suggest that periods of elevated temperature may further complicate waterhemp management by increasing the effectiveness of metabolic resistance mechanisms.

148 - Screening for herbicide resistance in Ohio waterhemp populations

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Waterhemp (*Amaranthus tuberculatus*) is an increasingly problematic weed in soybean production systems in Ohio, USA, owing to its potential to survive herbicide applications and contribute seeds to the soil-seedbank. Monitoring herbicide responses of field-derived populations is essential for identifying potential shifts in herbicide susceptibility and supporting effective weed management strategies. This study evaluated the responses of 18 waterhemp populations collected from 13 Ohio counties to four post-emergence herbicides. Seed collection surveys were conducted in soybean fields during fall, from 2018 to 2021, before harvest. Mature seed heads were collected from 5-10 plants per field appeared likely to exhibit herbicide tolerance based on visual assessment, cleaned, stored at -6 to 4°C, approximately 50% relative humidity and stratified for 30 days to enhance germination. Seeds were sown in peat-based media in plastic trays (27.7×54.5×6.2 cm) in greenhouse at Kottman Hall, Columbus. Plants were thinned to 20-30 plants per tray where germination permitted. Greenhouse temperature was maintained at 25.5°C during the day and 21.0°C at night, with 16-hour photoperiod. Trays were repositioned weekly and irrigated three times daily to maintain moisture. Glufosinate (1.75, 7.01 L ha^{-1}), 2,4-D (2.34, 9.35 L ha^{-1}), mesotrione (0.22, 0.88 L ha^{-1}) and fomesafen (0.44, 1.75 L ha^{-1}), were evaluated at 1× and 4× rates, except fomesafen (0.25×, 1×), alongside an untreated-check (UTC) for each population. Herbicides were applied when plants reached 7-14cm in height using a mechanized spray chamber calibrated to deliver 140 L ha^{-1}. Plant mortality was assessed visually at 14 days after treatment and expressed as the percentage of dead plants relative to the initial population. The populations were classified into four risk categories based on their mortality responses to different herbicides. Under glufosinate (4× rate), five populations (5-Crawford, 7-Pickaway, 13-Hardin, 20-Van Wert and 24-Putnam) indicating no apparent risk (100% mortality) of resistance. Six populations (8-Union, 5-Crawford, 7-Pickaway, 13-Hardin, 20-Van Wert and 24-Putnam) were listed as possible risk (95-100% mortality) of resistance; however, five of these

populations also recorded no apparent risk. The 17 populations were classified as having a moderate risk (50-95% mortality) of resistance across glufosinate, 2,4-D and fomesafen application. These included populations from 3-Delaware, 8-Union, 9-Union, 5-Crawford, 7-Pickaway, 10-Madison, 28-Madison, 13-Hardin, 26-Hardin, 18-Paulding, 19-Van Wert, 20-Van Wert, 1-Clarke, 11-Clarke, 21-Brown, 24-Putnam and 2-Green. Notably, 1-Clarke exhibited exactly 50% mortality under glufosinate (4×). Furthermore, high risk of resistance (<50% mortality) was indicated in all 18 populations under one or more herbicide treatments except glufosinate 4×, particularly mesotrione (1× and 4×), 2,4-D (1× and 4×), fomesafen (0.25× and 1× in certain populations) and glufosinate (1× in 1-Clarke), indicating substantial variation in herbicide responses among the tested waterhemp populations. Glufosinate generally showed no apparent risk to high risk, whereas mesotrione shows high risk, moderate high to high risk responses by 2,4-D and possible risk to high risk with fomesafen but varied widely. These findings emphasize the importance of population-specific herbicide response monitoring and integrated weed management to improve waterhemp control and reduce the potential for further evolution and spread of herbicide resistance in soybean production systems.

149 - AmaranthusDB: An Integrated Genomic Resource for Comparative Genomics in Amaranthus

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The genus *Amaranthus* includes some of the most damaging herbicide-resistant weeds in North American cropping systems, notably Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus*), as well as domesticated grain and vegetable crops. Although chromosome-level assemblies now exist for many *Amaranthus* species, genus-focused resources have not kept pace: the only accessible *Amaranthus* database is limited to population genetics of grain amaranths on a single reference genome, and broader weed genomics platforms are not designed for comparisons within the genus. We present AmaranthusDB, an integrated database of 43 genome assemblies from 12 weedy, cultivated, and wild species, built to let researchers move from a single gene to genus-wide patterns in a few steps. Users can search functionally annotated genes by identifier, description, Gene Ontology term, or pathway, open gene pages with structure, neighboring genes, and downloadable sequences, run BLAST, and view any region in an embedded JBrowse 2 genome browser. Comparative genomics is explored at three scales. Interactive dot plots display every collinear gene pair between two assemblies, can be filtered by chromosome, and let users click any block to inspect its genes. Ribbon-style synteny plots trace collinear blocks, inversions, and chromosomal rearrangements across multiple genomes, and a microsynteny viewer shows conserved gene order surrounding a gene of interest, allowing users to follow candidate loci such as herbicide targets or detoxification genes across species. An expression atlas presents curated RNA-sequencing experiments as interactive heat maps, allowing users to query one or many genes and compare expression across tissues, developmental stages, and stress treatments. Additional modules include a pangenome browser, a population diversity browser that reports diversity and differentiation statistics for grain amaranths and wild relatives, a trait browser linking published quantitative trait loci, association signals, and resistance genes to genomic positions, and resources for markers, germplasm, and

bulk downloads. AmaranthusDB provides weed scientists with a single, extensible platform for connecting genes, genome structure, and expression across weedy and cultivated *Amaranthus* species.

150 - Bridging Spectral Signatures and Multi-Omics to Advance Understanding of Molecular Mechanisms and Plant Responses to Herbicides

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The herbicides 2,4-D and glyphosate have been widely used for weed management in commercial crop production systems for more than five decades. The introduction of herbicide-resistant soybean traits enabled the post-emergence application of these herbicides during the growing season and significantly improved weed control compared to conventional management practices. However, their expanded use has also increased the risk of off-target movement, leading to unintended exposure and injury in sensitive crops, including non-GMO soybean. While recent studies in plant phenotyping can effectively capture visible and physiological responses to herbicide exposure within 24 hours of application (Niu et al. 2025), the underlying biochemical mechanisms driving these phenotypic changes remain poorly understood. To address this knowledge gap, our study was designed to combine high-throughput plant phenotyping, hyperspectral imaging, and multi-omics analyses to determine whether measurable changes in spectral reflectance are associated with molecular or genetic factors. Non-destructive hyperspectral imaging was performed at the whole-plant (< 3 m standoff cameras) and leaf (contact scan) levels, and spectral and spatio-spectral features derived from the hyperspectral data cubes were screened to identify features that best distinguished the herbicide treatments. Leaves from all imaged plants were sampled for transcriptomic and untargeted metabolomic profiling. Relative to mock-treated plants, glyphosate and 2,4-D altered 3,517 and 469 genes, respectively. Glyphosate uniquely induced jasmonate, salicylic acid, and immune-receptor signaling genes and repressed photosystem II and steroid biosynthesis genes, whereas 2,4-D uniquely induced auxin-responsive genes and repressed cell wall and glutathione metabolism genes. Integrating co-expression modules with metabolite and spectral profiles linked these molecular responses to herbicide-specific leaf signatures. These findings provide molecular insights into herbicide-induced responses that may underlie the distinct imaging signatures of these herbicides in soybean.

NCWSS Student Contest Papers - IWM

151 - Optimizing Cover Crop Integration for Weed Management in Bell Pepper Production

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[1]The Ohio State University

Cereal rye (*Secale cereale*. L) cover crop is an important integrated weed management strategy in vegetable crops to overcome the scarcity of viable herbicide options. However, high cover crop biomass, although desirable for weed suppression, can create management challenges for vegetable growers, especially during crop establishment. Therefore, field experiments were conducted in 2026 in Fremont and Wooster, OH to evaluate the effect of cover crop termination methods and herbicide program on weed control and bell pepper yield (*Capsicum annuum* L.). A split-plot design with four replications was used. The main factor consisted of five methods of preplant field preparation following a burndown application of glyphosate: 1) cover crop left standing, 2) cover crop roller-crimped, 3) cover crop flail mowed, 4) no cover crop, 5) no cover crop with tillage. Sub-factor included no herbicide or clomazone 560 g ai ha^{-1} + S-Metolachlor 1,407 g ai ha^{-1} applied preemergence (PRE). Due to significant interaction between treatment and site, data for each site were analyzed separately. At termination, cover crop was 39 cm and 38 cm tall and produced 6,990 kg ha^{-1} and 9,230 kg ha^{-1} aboveground biomass at Wooster and Fremont, respectively. At both sites, cover crop reduced aboveground weed biomass by at least 83% compared with no cover crop regardless of herbicide at 4 weeks after planting (WAP). However, at 9 and 12 WAP, weed biomass in cover crop without herbicide did not differ from no cover crop. Weed biomass did not differ among cover crop termination methods throughout the season. Overall, a PRE was needed in cover crop treatments to achieve consistently low weed biomass comparable to tillage with PRE standard treatment. Similarly, bell pepper marketable yield did not differ among cover crop treatments in the presence of PRE and was comparable to the highest yield producing tillage with PRE standard treatment. Cover crops without PRE did not improve bell pepper marketable yield compared with no cover crop. These results indicate that cover crop termination methods have little effect on weed control effectiveness, but a strong PRE herbicide program is needed in conjunction with cover crop to achieve season long weed control and maintain crop yield.

152 - Optimizing Cover Crop Termination for Soil Moisture and Weed Suppression

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Cereal rye as a fall-planted cover crop can suppress weeds and can be used as an integrated weed management option along with herbicides in agronomic crops such as soybean. Weed suppression depends largely on cover crop biomass, which is influenced by several factors, including termination timing in the spring. However, delayed termination may increase competition with soybean for soil moisture and nutrients, and large amount of biomass can hinder the earlier crop growth. Field experiments were conducted in 2024 and 2025 at Rosemount, MN, to evaluate the effects of cereal rye termination timing and herbicide inputs on soil moisture, weed suppression, and yield. Termination treatments included no cover crops (NCC), termination one week before planting (TBP), at planting (T0), one week after planting (T1), and two weeks after planting (T2). Herbicide programs consisted of low input (PRE-only) and high input (PRE followed by POST) treatments. Treatments were arranged in a split-plot design, where cover crop termination was main plot and herbicide input was subplot factors. In 2024, delaying termination by two weeks (T2) reduced profile soil water at soybean emergence by 21% compared to the no-cover-crop control (NCC). However, termination timing did not significantly affect

profile water storage from soybean emergence to the R1 growth stage in 2024, or at any measured stage during the 2025 growing season. Herbicide input had no significant effect on profile water storage. Weed density and biomass was significantly reduced by delayed cereal rye termination compared with the earlier termination and no-cover-crop control. In 2024, dandelion biomass declined from 21.3 g m^{-2} in NCC to 1.9 g m^{-2} in T2, while yellow foxtail biomass decreased from 49.2 to 4.2 g m^{-2} in the same treatments. In 2025, delayed termination reduced giant ragweed biomass from 129 to 2.3 g m^{-2}, yellow foxtail biomass from 114.1 to 9.1 g m^{-2}, and common lambsquarters biomass from 19.2 g m^{-2} in T2 compared to NCC. Soybean yield was not affected by termination timing or herbicide input. The results from this research showed that delaying cereal rye termination improved weed suppression without consistently affecting soil moisture storage or reducing soybean yield.

153 - Effects of Cover Crops and Micro-Encapsulated Formulation on Acetochlor Runoff and Surface Water Contamination

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Acetochlor, a common active ingredient in corn preemergence herbicides, has been repeatedly detected in surface waters in Minnesota, prompting concerns regarding potential adverse effects on aquatic ecosystems, water resources, and human health. To maintain the utility of acetochlor while reducing its transport potential, best management practices (BMPs) have been proposed. These include cover cropping, which may reduce runoff and erosion, improve soil structure and infiltration, and promote herbicide biodegradation. Moreover, microencapsulated acetochlor formulations provide slower acetochlor release and may increase soil retention. To evaluate the effects of cover crops and microencapsulation on acetochlor transport, a field experiment was conducted in a continuous corn production system at the University of Minnesota’s Southern Research and Outreach Center in Waseca, MN, during the 2025 growing season. The experiment used a randomized complete block design with a 3 × 3 factorial arrangement of three fall-established cover crop treatments (no cover crop, cereal rye [winter-hardy], and an oat/radish/pea mixture [winter-killed]) and three acetochlor treatments (no acetochlor, microencapsulated acetochlor, and non-microencapsulated acetochlor). Soil samples were collected 1 day before and at 3, 14, 28, and 56 days after acetochlor application and analyzed for acetochlor residues using liquid chromatography-tandem mass spectrometry to evaluate soil persistence. Microbial biomass carbon and nitrogen were quantified using the chloroform fumigation-extraction method, while 16S rRNA sequencing is being conducted to characterize bacterial and archaeal community composition in response to the treatments. Water samples from subsurface tile drainage systems were also collected following rainfall events throughout the growing season and analyzed for acetochlor residues using the same analytical method to assess potential off-site movement. Preliminary results showed no effect of cover crop treatments on acetochlor persistence; however, the percentage of microencapsulated acetochlor remaining in the soil at 28 and 56 days after application (35.5% and 52.0%, respectively) was greater than that of non-microencapsulated acetochlor (12.9% and 6.48%, respectively). Microbial biomass carbon and nitrogen, as well as corn silage yield, did not differ among treatments. Acetochlor was not detected in any subsurface tile drainage water samples. Data collection was repeated in 2026 to supplement the 2025 dataset and strengthen conclusions regarding the environmental implications of

these BMPs. These preliminary results suggest that microencapsulated acetochlor may alter the timing of acetochlor release and potential transport while prolonging its persistence in soil.

154 - Responses of Waterhemp (*Amaranthus tuberculatus*) and Common Purslane (*Portulaca oleracea*) to Cereal Rye Cover Crop Biomass in Sweet Corn

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Cereal rye (*Secale cereale* L.) is the commonly used cover crop because of high biomass production which is directly proportional to its weed suppression potential. However, the effects of varying cover crop biomass levels on weed and crop performances are not known beyond low and high biomass effects achieved through early and late terminations. Therefore, field experiments were conducted in 2026 at two sites, South Charleston and Fremont, OH to evaluate the biomass-response of cereal rye on multiple-herbicide resistant waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer], common purslane (*Portulaca oleracea*) and sweet corn (*Zea mays* L. var. saccharata) performances. Six cereal rye biomass levels achieved through six termination dates were compared with S-metolachlor + atrazine + mesotrione + bicyclopyrone (premix) and S-metolachlor applied preemergence (PRE) using a strip-plot design with four replications. At South Charleston, cereal rye provided waterhemp control comparable to S-metolachlor (30 % control) at 3,100 kg ha^{-1} and premix (88% control) at 13,100 kg ha^{-1}. At Fremont, cereal rye needed 14,600 kg ha^{-1} to achieve common purslane control comparable to S-metolachlor (88 % control) and did not achieve common purslane control comparable to premix (97 % control). Cereal rye biomass greater than 9,000 kg ha^{-1} delayed sweet corn emergence at both sites and reduced final plant stand by up to 65% at Fremont. At South Charleston, sweet corn yield showed a quadratic response to rye biomass levels, reaching to 10,500 kg ha^{-1} at 7,200 kg t ha^{-1} rye biomass, compared to 15,000 kg ha^{-1} in premix treatment. At Fremont, cereal rye reduced sweet corn yield by 53 to 85% compared with PRE herbicides across rye biomass of 2,300 to 15,100 kg ha^{-1}, primarily due to poor crop stand. These results suggest that favorable effects of cereal rye cover crop are variable and are site and weed species dependent.

155 - Optimizing Cover Crop Termination Timing to Manage Waterhemp and Minimize Shade Avoidance in Soybean.

Steven Tri[1], Estefania Polli[1], Rocco D'Antico[1], Ethan Easter[1], Caroline Backes[1], Tunde Akanbi[1], Iththiphonh Macvilay[1], Damian Franzenburg[1], Mark Licht[1], Wesley Everman[1]

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Waterhemp (*Amaranthus tuberculatus*) is a major challenge in soybean (*Glycine max*) production due to its competitive ability and widespread resistance to multiple herbicide modes of action. Adoption of cover crops, such as cereal rye (*Secale cereale*), can suppress waterhemp emergence by producing biomass that

limits light availability at the soil surface. However, cover crop termination timing may influence both weed suppression and soybean growth. Therefore, research is needed to evaluate the effects of cereal rye termination timing on waterhemp control and soybean growth across two weed management systems and row spacings. A field experiment was conducted at Curtiss Farms in Ames, Iowa, in 2026. Treatments were arranged in a 2 x 2 x 5 factorial design with four replications. Factors included two soybean row spacings (38.1 and 76.2 centimeters), two weed management systems (weed-free and weedy), and five termination timings (7 days prior to planting, at planting, 7 days after planting,14 days after planting, and no-cover control). Cereal rye biomass was sampled immediately before each termination timing. At 42 days after planting (DAP), waterhemp control was visually estimated relative to the non-treated control, density was recorded, and aboveground biomass was collected. Soybean height was also recorded at 42 DAP. Soybean stand and pod counts were recorded prior to harvest. Data analysis was conducted in SAS software using the PROC GLIMMIX procedure, and means were separated using Tukey's test at alpha = 0.05. Waterhemp suppression improved as cereal rye termination was delayed. Differences in waterhemp control and biomass between weedy and weed-free treatments were not significant when rye was terminated at planting or later, suggesting that cereal rye at these timings helped reduce waterhemp. For soybeans, pod production decreased from 63 pods per plant in the weed-free treatment to 43 pods per plant in the weedy treatment. Additionally, a higher soybean stand count was observed in the 76.2-cm row spacing compared to the 38.1-cm row spacing. Termination at planting also had a higher soybean stand count observed when compared to 7 days before planting. These results suggest that delaying cereal rye termination may improve waterhemp suppression and that termination timing, weed competition, and row spacing are important factors affecting soybean growth.

156 - Carryover Potential and Sensitivity of Fall-Planted Cover Crop Species to Preemergence Applications of Diflufenican and Mesotrione

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The increased adoption of no-tillage in corn-soybean cropping systems and the continued evolution of herbicide-resistant weeds have emphasized the importance of residual herbicides for effective season-long weed control. At the same time, the use of fall-planted cover crops has been increasingly popular, raising concerns among growers in the U.S. Midwest about residual herbicide carryover to subsequent cover crops. The potential for herbicide carryover is a function of the sensitivity of the crop to the herbicide and the persistence of the herbicide in the soil. Diflufenican is expected to be used commercially in U.S. corn and soybean production in 2027. Since limited information on the potential for carryover to cover crops for diflufenican is available, a comparison of cover crop sensitivity diflufenican relative to a commercial standard of mesotrione would be informative. Therefore, the objective of our research was to conduct a greenhouse bioassay experiment on the sensitivity of cover crop species to preemergence applications of these herbicides across a range of application rates. The sensitivity of cereal rye (*Secale cereale* L.), wheat (*Triticum aestivum* L.), canola (*Brassica napus* L.), hairy vetch (*Vicia villosa* R.), and tillage radish

(*Raphanus sativus* L.) was quantified following preemergence applications of diflufenican or mesotrione at 0x, 1x, 2x, 4x, 8x, and 16x rates, with 1x corresponding to 150 and 210 g ai ha^{-1}, respectively. When increasing the rate of these herbicides up to 16X the normal use rate, the shoot biomass of wheat and cereal rye was not impacted at 21 DAP, indicating a high level of tolerance in these species to the herbicides. However, the dicot cover crop species exhibited greater sensitivity to mesotrione than to diflufenican, with sensitivity ranked as tillage radish > canola > hairy vetch for mesotrione and canola > tillage radish > hairy vetch for diflufenican. This greenhouse experiment establishes the relative sensitivity of the cover crop species to diflufenican compared with mesotrione. A field experiment has been initiated to document the extent of soil persistence and carryover of these herbicides to guide future herbicide recommendations in cover crop systems.

157 - Effects of Rye Cover Crop, Residual Herbicides, and MSO Use on Palmer amaranth (*Amaranthus palmeri*) Control in Soybean

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Cereal rye (*Secale cereale* L.) cover crop (CC) and soil-residual herbicides help manage herbicide-resistant Palmer amaranth (*Amaranthus palmeri* S. Watson) in soybean [*Glycine max* (L.) Merr.]. However, residual herbicides with both soil and foliar activity, such as flumioxazin, may be retained on living CC tissue and adding an adjuvant such as methylated seed oil (MSO) may increase this retention, resulting in less soil activity. On-farm studies in 2025 and 2026 near Oak Hill, KS, evaluated two CC conditions at application, dead (terminated 10 d before soybean planting) and living (terminated at planting), and five herbicide mixtures: no residual herbicide (control), dimethenamid-P (soil activity only) or flumioxazin (both), each with or without MSO. A no-CC plot was added in 2026. Living CC produced up to 22% more biomass than dead CC in both years but spray interception did not differ between CC conditions. Flumioxazin-containing mixtures reduced early-season Palmer amaranth emergence in both years, time to 10% emergence was delayed to 28 d after herbicide application, compared to 3 days with no residual herbicide. Dimethenamid-P-containing mixtures did not differ in emergence from the control. At soybean canopy closure in both years, flumioxazin-containing mixtures reduced Palmer amaranth density by 85 to 87% relative to the no residual herbicide (control) and had 71 to 82% less Palmer amaranth biomass than dimethenamid-P-containing mixtures with either CC condition, and 87% less with no CC in 2026. There was no effect of CC condition, nor a consistent benefit of adding MSO on Palmer amaranth density or biomass. Soybean yield was 8% greater with dead than living CC in 2025 but was not different in 2026. Herbicide mixtures did not affect yield, but flumioxazin cost \$21 ha^{-1} less than dimethenamid-P. In 2025, the dead CC condition, despite greater cost, had a \$70 ha^{-1} greater gross margin than the living CC condition. Flumioxazin did not reduce its soil-residual activity in living CC conditions as a trade-off for foliar activity and showed consistent Palmer amaranth control regardless of CC condition or MSO inclusion.

158 - Building a Weed Management System: Assessing the Role of Residual Herbicides, Cereal Rye, Soybean Planting Date, and Targeted Herbicide Applications

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Integrated weed management is a systems-based approach that combines complementary tactics to improve weed control in soybean production systems. However, the integration of targeted herbicide applications into these systems remains unexplored. Thus, a field trial was conducted in 2026 near Francesville, Indiana, arranged as a randomized complete block design with 20 treatment combinations. The first treatment factor consisted of two levels; "yes" or "no", representing whether residual herbicides were included or not into the preemergence (PRE) herbicide program. The second factor consisted of five soybean-cereal rye cover crop management levels: early planted soybean with no rye, early planted soybean with rye terminated at planting, early planted soybean with rye termination delayed until two weeks after planting, late planted soybean with no rye, and late planted soybean with rye terminated at planting. The third factor consisted of two postemergence (POST) application methods of 447 g ha^{-1} glufosinate-P-ammonium + 1,121 g ha^{-1} 2,4-D at V3-V4: broadcast-applied or targeted-applied using the Verdant Sharpshooter™. All treatments received a broadcast application of 1,261 g ha^{-1} glyphosate + 1,121 g ha^{-1} 2,4-D at planting or at cereal rye termination. Rye biomass was collected at termination when applicable, while waterhemp (*Amaranthus tuberculatus* [Moq.] J. D. Sauer) density and height were recorded at the POST application timing. Visual waterhemp control assessments were taken 21 days after the POST application treatment (DAPOST). Data were modeled in R 4.5.2, subjected to one-way ANOVA, and treatment means were separated using Tukey's HSD (α=0.05). Results indicated rye biomass at termination was 1.4, 3.1, or 7.0 Mg ha^{-1} for early planted soybean with rye terminated at planting, early planted soybean with rye terminated two weeks after planting, and late planted soybean with rye terminated at planting, respectively. Early planted soybean with PRE residuals and no rye or rye terminated at planting resulted in the lowest waterhemp density at POST among all treatments, averaging 42 and 50 waterhemp m^{-2}, respectively. Delaying rye termination by two weeks in early planted soybean regardless of residual inclusion in the PRE resulted in the lowest waterhemp height at POST among all treatments, averaging 4 cm. The lowest waterhemp control among all treatments at 21 DAPOST (35%) occurred in early planted soybean with rye terminated at planting, no PRE residual, and a target-applied POST. In contrast, the greatest waterhemp control at 21 DAPOST was observed in late planted soybean with rye terminated at planting and PRE residual herbicides applied, averaging 94% and 81% control with broadcast and targeted POST applications, respectively. These results suggest that targeted applications may have a role in integrated weed management practices. However, it is clear there is considerable complexity in these dynamic systems which does not allow for a "one size, fits all" approach and more research is needed to identify best use practices.

159 - Integrating Spring-Planted Cover Crops and Row Spacing with Herbicides for Weed Control in Soybean

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Rapid development and subsequent spread of herbicide-resistant weeds complicate weed management in soybean [*Glycine max* (L.) Merr.] production systems, highlighting the need for integrated strategies that combine herbicides with effective cultural practices. Cover crops (CC) can serve as an effective component of integrated weed management that suppresses weeds through early-season competition and biomass production. In the northern Great Plains, the short interval between crop harvest and cold temperatures can limit fall-planted CC establishment. Therefore, spring-planted CCs can serve as an alternative strategy for providing early-season ground cover and suppressing weeds during early crop establishment. Therefore, this study was conducted to evaluate the effects of spring-planted CCs, row spacing, and postemergence herbicide application (POST) on weed management and soybean yield. Field experiments were conducted in 2026 at two South Dakota locations using split-split-plot randomized complete block design with four replications. Main plot factor consisted of four CC treatments, and the two soybean row spacings as the sub-plot factor, and sub-subplot factor consisted of POST or no POST. At the Southeast Research Farm, treatments included spring oat (*Avena sativa* L.) and spring pea (*Pisum sativum* L.) seeded at 78 kg ha^{-1}, an oat + pea mixture seeded at 47 + 31 kg ha^{-1}, and a no-cover control. At Brookings County, treatments included spring oat and barley (*Hordeum vulgare* L.) seeded at 78 kg ha^{-1}, an oat + pea mixture seeded at 47 + 31 kg ha^{-1}, and a no-cover control. Soybean was planted in 38- and 76-cm row spacings. CCs were terminated 21 d after soybean planting and biomass was measured. POST treatments included glyphosate (1,546 g ai ha^{-1}) + glufosinate (447 g ai ha^{-1}) + 2,4-D (780 g ai ha^{-1}). Weed density and biomass were measured at termination and 30, 60, 90, and 120 d after termination (DAT), and soybean grain yield was measured at harvest. At Southeast Research Farm, total weed density at termination did not differ among CC treatments, but oat and oat + pea reduced total weed dry biomass by 54 and 57%, respectively, compared with the no-CC. Without POST, oat and pea reduced weed density by 90-95% at 30 and 60 DAT, and all CCs reduced weed dry biomass by >96%. No weeds were observed in CC treatments at 90 or 120 DAT. CC treatment and row spacing did not affect soybean grain yield, whereas a POST increased yield by approximately 7%. At Brookings oat, barley, and oat + pea reduced weed density by 97, 97, and 99%, respectively, and weed dry biomass by 91, 95, and 98% at termination. Without POST, CCs reduced weed density by 95-100% and weed dry biomass by 97-100% from 30 to 120 DAT. Soybean grain yield was not affected by CC treatment, row spacing, POST herbicide application, or their interactions. Row spacing did not significantly affect overall weed density or dry biomass at either location. Across locations, spring-planted CCs provided substantial and persistent weed suppression without a soybean yield penalty, supporting their use in integrated weed management.

160 - Planting Date Effects on Weed Suppression in Dry Bean Across Three Growing Seasons

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Dry beans mature in roughly 100 days, giving growers flexibility to plant later and harvest earlier than in typical corn and soybean systems. Although Michigan dry beans are traditionally planted in early June, recent studies suggest potential agronomic benefits to earlier planting dates in other crops, such as soybeans along with the trend towards earlier and longer growing seasons have increased interest in planting earlier. This research aims to investigate the agronomic and weed control implications of planting black beans earlier in conventional weed management systems. Six field experiments were established between 2024 and 2026 at two locations: the Michigan State University Agronomy Farm (MSU; East Lansing, MI) and the Saginaw Valley Research and Extension Center (SVREC; Frankenmuth, MI). Each experiment was a split-plot randomized complete block design with planting date as the main plot factor and weed control program as the subplot factor. The three planting dates included “ultra-early” (targeting the 1st week of May), “early” (3rd week of May), and “normal” (1st week of June). Weed management systems included (1) PPI pendimethalin (1,060 g ha^{-1}) + dimethenamid-P (578 g ha^{-1}) alone, (2) followed by (fb.) POST imazamox (35 g ha^{-1}) + bentazon (733 g ha^{-1}), (3) fb. POST imazamox + bentazon + dimethenamid-P (526 g ha^{-1}), and (4) fb. POST imazamox + bentazon + dimethenamid-P fb. late postemergence (LPOST) fomesafen (280 g ha^{-1}) 5 d after POST. Precipitation varied between sites, with the driest and wettest growing seasons (May - Sept) being 2025 (36.4 cm) and 2026 (49.4 cm) at MSU and 2026 (45.4 cm) and 2024 (50.6 cm) at SVREC, respectively. Dry bean stand in 3 of the 6 site-years was 13 to 60% lower for “ultra-early” planted beans compared with the “normal” planting. “Early”-planted dry bean stands were 20% and 8% lower than “normal” for MSU 2026 and SVREC 2025, respectively. SVREC had lower, 93% less, weed biomass in untreated plots than MSU. Planting date effect on weed biomass was only significant at SVREC in 2025. Herbicide program influenced end-of-season weed biomass in 4 site-years, where PPI treatments reduced weed biomass by 32 to 88%. PPI fb. POST programs at MSU reduced weed biomass by 90 - 97%. Dry bean yield was affected by planting date in 4 site-years and by herbicide program in 5 of the 6 site-years. At MSU in all three years, the highest-yielding treatment across planting dates was PPI fb. POST imazamox + bentazon + dimethenamid-P. Averaged over the three years, black beans planted at the normal time at MSU yielded ~17% more than the early and ultra-early planting times; however, the ultra-early planting at SVREC yielded ~17% more than early or normal planting. Success of planting dry beans earlier is highly location- and weather-dependent, with potential for yield losses at earlier planting times outweighing yield gains compared with a normal planting time.

161 - Influence of Row Width and Canopy Architecture on Weed Suppression in Winter Wheat

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Effective weed management in winter wheat (*Triticum aestivum*) relies on a combination of herbicides and crop competition. Rapid canopy closure can suppress weed emergence and growth. This study evaluated how different combinations of row width, canopy architecture, and herbicide applications affect weed control in winter wheat. A field experiment was conducted during the 2025-2026 winter wheat

growing season at Michigan State University (MSU) Agronomy Farm in East Lansing and at the Saginaw Valley Research and Extension Center (SVREC) near Richville, MI. This study was set up as a split-split-plot randomized block, with row width (14 and 19 cm) as the main plot, wheat canopy architecture (upright and lateral) as the sub-plot, and herbicide treatment as the sub-sub-plot. Herbicide treatments consisted of a non-treated control and a combination of mesosulfuron-methyl (15 g ha^{-1}) and bromoxynil (230 g ha^{-1}) with pyrasulfotole (42 g ha^{-1}) applied in the fall and spring. At both locations, the herbicide combination applied in the spring caused 5 to 10% injury to wheat 7 d after application. However, wheat recovered from this injury by the 14 d evaluation. There was no injury observed from the fall applications of this mixture. Regardless of row width, the lateral canopy reached 75% canopy closure 9 to 14 d earlier than the upright canopy at MSU. However, at SVREC both the lateral and upright canopy of wheat planted in narrow rows and the lateral canopy in 19 cm rows reached 75% canopy closure 5 to 11 d earlier than the upright canopy. Weed populations were too low at SVREC for evaluation. Winter annuals at MSU included common chickweed (*Stellaria media* (L.) Vill.) and henbit (*Lamium amplexicaule* L.). Winter annual weed control from the fall herbicide application was >95%, while control from the spring application was 83-89%. At 28 d after the spring application, there was a herbicide by canopy architecture interaction for common ragweed (*Ambrosia artemisiifolia* L.) control. The spring herbicide application provided 100% common ragweed control. Within the fall herbicide application, the lateral canopy had 52% control, and the upright canopy had 14% control. Suggesting that the lateral canopy suppressed common ragweed emergence and growth. The spring herbicide application reduced winter annual counts by 60 to 90%. In late June, the tiller angle of the lateral and upright canopies at SVREC were similar, while the lateral and upright canopies at MSU were 11º and 6º, respectively. Regardless of row width, canopy architecture, and herbicide, there was no difference in yield at MSU. However, at SVREC, there was a 7% reduction in yield from the spring herbicide application. Overall, row width had very little effect on weed control or wheat yield. Fall herbicide applications provided greater winter annual weed control than spring herbicide applications, whereas spring herbicide applications were necessary for effective common ragweed control. A lateral canopy architecture improved common ragweed control in the absence of a spring herbicide application, showing the suppressive ability of competitive canopy architecture.

162 - Influence of mulch types and planting density on weed control and yield in transplanted edamame in a raised-bed system

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Edamame (*Glycine max* (L.) Merr.) is a high-value specialty crop with rapidly growing U.S. demand. U.S. consumers prefer locally grown, fresh, and organic edamame and are willing to pay a premium, yet domestic production remains limited because best management practices, including weed management, have not been established. We evaluated three mulch types (polyethylene, recycled polyethylene, and biodegradable) and two planting densities (high: 287,038 plants ha^{-1}; low:143,519 plants ha^{-1}) for weed control and yield of transplanted edamame in a raised-bed system, using a split-plot field trial replicated four times in Lincoln, Nebraska. Yellow foxtail (*Setaria pumila*) was the dominant weed species. All three mulches suppressed weeds and protected yield. Three weeks after transplanting, weed density was 83%

lower with polyethylene mulch and 66% lower with recycled polyethylene and biodegradable mulches than in the weedy check ($P < 0.01$). At harvest, weed biomass was 62%, 61%, and 69% lower with polyethylene, recycled polyethylene, and biodegradable mulch, respectively ($P < 0.01$). The weedy check yielded 36% less than the weed-free check, whereas yields with the three mulch types did not differ from each other or from the weed-free check and were 54%, 57%, and 43% greater, respectively, than the weedy check ($P < 0.01$). High planting density yielded 40% more than low planting density without reducing 100-pod weight, an indicator of yield quality. These results show that polyethylene, recycled polyethylene, and biodegradable mulches, combined with high planting density, can control weeds and increase yield without lowering the quality of transplanted edamame, giving growers a nonchemical weed-management option for a best-management-practices framework.

163 - Effects of Cereal Rye Fall Planting Date, Seeding Rate, Variety, and Termination Time on Spring Biomass Accumulation and Implications for Soybean Planting Green in Wisconsin

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Cereal rye (*Secale cereale*) is one of the most common cover crops in the U.S. Midwest due its cold tolerance, high spring biomass production, and weed suppression capacity. Achieving sufficient biomass for effective weed suppression can be challenging under the short cover crop growing season in corn-soybean rotations across the Upper Midwest. The objectives of this study were to quantify the independent and interactive effects of fall planting date, seeding rate, and variety selection on cereal rye spring biomass accumulation and the effects of spring cereal rye termination timing on soybean stand establishment and yield. Field experiments were established at Arlington Agricultural Research Station in the fall of 2024-2025 soybean season (2024-2025) and replication in the fall of 2025-2026 soybean season (2025-2026), in a randomized complete block design with 4 replications of each treatment. The study consisted of a 2x2x2x2 factorial. The first factor was the cereal rye planting date: early (end of September) versus late (end of October). As a second factor, two different cereal rye seeding rates were tested: 45 and 67 kg ha^{-1}. The third factor was composed of two cereal rye varieties: Bin run and Aroostook (2024-2025), and Bin Run and ND Gardner (2025-2026). Finally, the fourth factor was the cereal rye termination time: early (at soybean planting time), versus late (when cereal rye reached 76 cm in height or soybeans reached emergence growth stage, whichever happened first). Cereal rye was terminated with glyphosate (1,262 g ae ha^{-1}) + ammonium sulfate (3,363 g ha^{-1}). Cereal rye height was recorded and biomass collected at each termination time. Early cereal rye planting in the fall resulted in a biomass increment greater than 24% compared to late planting when cereal rye was terminated early in the spring. Increasing the seeding rate generally did not increase cereal rye biomass with early cereal rye planting, regardless of termination timing. With late planting in the fall, the higher seeding rate increased cereal rye biomass by 37% in both years, but only under late spring termination. Cereal rye varieties tested herein performed similarly across all planting, seeding rate, and termination time scenarios. In 2025, soybean yield had a reduction of 7% only when early-planted cereal rye was terminated late; no yield differences were observed under the other management strategies. Soybean yield data from 2026 are

being analyzed and will be presented at the conference. Fall planting date and termination timing were the main factors affecting cereal rye biomass production in the spring, emphasizing the importance of these management decisions within the short Upper Midwest cover crop growing season.

164 - Terminating Cereal Rye After Soybean Planting: When Should Residual Herbicides Be Applied?

Guilherme Chudzik[1], Jose Jr Nunes[1], Ryan DeWerff[1], Karla Gage[2], Kevin Bradley[3], Larry Steckel[4], Jason K Norsworthy[5], Joe Ikley[6], Sarah Lancaster[7], Travis Legleiter[8], Christy Sprague[9], Alyssa Essman[10], Tommy Butts[11], Bryan G Young[11], Rodrigo Werle[1]

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Early soybean planting creates a longer interval between crop planting and peak emergence of the troublesome weeds Palmer amaranth (*Amaranthus palmeri* S. Watson) and waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer], both of which exhibit prolonged emergence patterns. This presents challenges and opportunities for residual herbicide application time, as early applications at crop planting may provide insufficient residual activity during later weed emergence periods. Later residual herbicide applications may provide greater weed suppression during peak weed emergence periods. In addition to optimizing residual herbicide application timing, integrating cereal rye provides an additional opportunity to suppress weed emergence. Moreover, delaying cereal rye termination until after soybean planting (i.e., planting green) allows for greater biomass accumulation, potentially enhancing weed suppression. This study evaluated the impact of delayed cereal rye termination and residual herbicide application timing on *Amaranthus* spp. density and height at the time of postemergence (POST) herbicide application and end-of-season biomass. Field experiments were conducted in 2025 and 2026 across 11 U.S. states (AR, IL, IN, KS, KY, MO, MI, ND, OH, TN, and WI) as a 5 x 2 factorial in a randomized complete block design with four replications. Five management strategies were evaluated: cereal rye termination at soybean planting without a residual herbicide, termination at planting with a residual herbicide applied at planting, delayed termination without a residual herbicide, delayed termination with a residual herbicide applied at planting, and delayed termination with a residual herbicide applied at termination. Delayed termination occurred at soybean VE or when cereal rye reached 76 cm in height, whichever occurred first. These strategies were combined with two POST herbicide programs (with or without POST). Delaying cereal rye termination without a residual herbicide reduced *Amaranthus* spp. density and height at POST by 46 and 45% across site-years, respectively, compared with early cereal rye termination without residual herbicides. Adding residual herbicides to both cereal rye termination strategies reduced *Amaranthus* spp. density by 77 to 94% and height by 42 to 74%, respectively. POST herbicide applications reduced end-of-season *Amaranthus* spp. biomass by 71% compared with treatments without POST. These results highlight the value of integrating delayed cereal rye termination with residual and POST herbicides for improving *Amaranthus* spp. management in early-planted soybean systems.

NCWSS Student Contest Papers - Weed Genetics & Herbicide Physiology

165 - Mechanism of Glufosinate Resistance in Waterhemp (*Amaranthus tuberculatus*)

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Waterhemp (*Amaranthus tuberculatus*) has become one of the most problematic weeds in agronomic cropping systems due to the widespread evolution of herbicide resistance. Multiple studies identified glufosinate, a glutamine synthetase (GS)-inhibiting herbicide (WSSA Group 10), as an effective postemergence option to control such herbicide-resistant waterhemp populations. However, recently, failed waterhemp control upon glufosinate application at label recommended dose was observed for a population from Dodge County in Minnesota, raising concerns about the evolution of resistance to this herbicide. Greenhouse and laboratory experiments were conducted at University of Minnesota to confirm resistance and investigate the underlying genetic and physiological mechanisms in this population. Greenhouse whole-plant glufosinate dose-response assays indicated a 2.8 to 3.0-fold resistance index relative to the susceptible populations. Waterhemp genome annotation was parsed to identify *GS* genes, including two encoding cytosolic isoforms (*GS1.1* and *GS1.2*) and two encoding plastidic isoforms (*GS2.1* and *GS2.2*). Sequence analysis revealed no nonsynonymous mutations in the coding sequences of any of the four GS genes. Similarly, analyses of gene copy number and transcript abundance revealed no differences between resistant and susceptible populations for any of the four GS genes. Glufosinate residue was quantified in plant leaves at 1, 3, and 7 d after treatment by rinsing the leaves with distilled water, extracting residues in methanol followed by quantification using liquid chromatography-mass spectrometry (LC-MS). Resistant plants contained significantly lower leaf glufosinate residues than susceptible plants, with reductions of 65 to 69% at 3 d and 49 to 63% at 7 d after treatment. Our results demonstrated lower glufosinate residue levels in plants from resistant population compared to the susceptible ones, suggesting the involvement of non-target-site resistance mechanisms, potentially involving differences in herbicide absorption or metabolic detoxification.

166 - Development of a Hydroponic Screening Method to Characterize Corn Hybrid Sensitivity to Amicarbazone and Metribuzin

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Atrazine, a photosystem II (PSII)-inhibiting herbicide, is a common component in corn (*Zea mays*) herbicide premixtures due to its broad-spectrum weed control and high degree of crop safety. However, the utility of atrazine can be limited in areas where atrazine-resistance is prevalent or groundwater contamination is of concern. Thus, identifying other PSII-inhibiting herbicides that could be utilized in corn production is imperative. Amicarbazone and metribuzin are PSII-inhibiting herbicides registered for use in corn, but differential corn response across hybrids needs to be characterized to meet commercial concerns. The objectives of this study were to modify a hydroponic assay to 1) characterize the response of two corn hybrids, one with above- and one with below-average tolerance to amicarbazone and metribuzin, to establish a discriminating dose and 2) use these benchmark hybrids to screen additional corn genetics for sensitivity to amicarbazone or metribuzin using the discriminating doses. Experiments were conducted in a growth chamber and consisted of two factors: herbicide dose (0 ppb, 6400 ppb amicarbazone, or 6400 ppb metribuzin) and corn hybrid (n=12). Uniform seedlings were introduced into the hydroponic system, acclimated in the growth chamber for 8 hours in complete darkness, then grown in cycles of 16 hours of light followed by 8 hours of darkness. Corn was harvested after five days of growth, when the nontreated plants reached the second leaf vegetative growth stage. Visual estimates of chlorosis, necrosis, and overall injury were assessed on a scale of 0 to 100. The first and second leaf were harvested, imaged with a flatbed scanner, and processed in Turfanalyzer to calculate the percent reduction in green leaf tissue. Data were converted to percent reduction of the nontreated control, and a principal component analysis (PCA) was conducted to determine the most relevant data types and number of distinct categories that could be formed. Data were analyzed with Welch’s t-test ($\alpha \leq 0.05$), with the mean of the tolerant and the sensitive benchmark hybrids compared to the mean of each hybrid of unknown tolerance for each trait, with correction for multiple comparisons. Of the 12 hybrids evaluated, three were classified as more sensitive, seven as sensitive, and two as tolerant to both herbicides, relative to the benchmark hybrids. These results indicate that a genotypic response to metribuzin and amicarbazone can be identified with a hydroponic assay, and that hybrid screening could be a tool to support commercial adoption of amicarbazone and metribuzin in corn production.

167 - Genetics Behind Post-Emergence Metribuzin Tolerance in MGIII Soybean

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[1]University of Kentucky

Soybean [*Glycine max* (L.) Merrill] is one of the largest US agricultural commodities. Weed interference, especially from pigweed species such as waterhemp (*Amaranthus rudis* J.D. Sauer) and Palmer amaranth [*Amaranthus palmeri* (S.) Wats.], can cause substantial yield losses. Due to herbicide resistance to multiple sites of action in waterhemp and Palmer amaranth, metribuzin is among the few effective options remaining for weed management in soybean. Improving metribuzin residual activity through an additional postemergence application can potentially enhance pigweed management. However, postemergence metribuzin tolerance is needed, and soybean currently lacks it. In a multi-trial augmented greenhouse study, we screened 1811 genetically diverse maturity group III (MG III) soybean accessions for postemergence metribuzin tolerance. Metribuzin was applied after soybean emergence at 300 g ai ha^{-1}, and the injury was rated 21 days after application (DAA). A genome-wide association study (GWAS)

identified fourteen markers on chromosomes Gm2, Gm3, Gm4, Gm5, Gm10, Gm13, Gm14, and Gm15 that were significantly correlated with the degree of postemergence metribuzin injury. The novel loci contained candidate genes encoding Cytochrome P450s (CYP71 clan), UDP-glucosyltransferase (UGT84B1), and ABC/PDR transporter (ABCG36/PDR8). This set of candidate genes corresponds to primary metabolic pathways associated with non-target site herbicide tolerance. Collectively, these findings reveal genetic architecture underlying postemergence metribuzin tolerance in soybean and represent a foundation for future functional validation and marker-assisted breeding to develop postemergence metribuzin-tolerant soybean cultivars.

168 - Utility of a Rapid Physiological Assay for Determination of Waterhemp (*Amaranthus tuberculatus*) Resistance to Fomesafen

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Multiple testing measures are used for resistance confirmation, but vary in time requirements, labor efficiency, accuracy, and cost. Molecular DNA assays using genetic markers, which are primarily based on polymerase chain reaction (PCR) or quantitative PCR, can provide a qualitative result within 24 hours of analysis. However, these tests are largely limited to detecting known target site (TSR) mutations that were previously confirmed to exist. Currently, whole-plant greenhouse assays starting with weed seed collected from escaped plants in the field at maturity is the most common method used to investigate instances of non-target site resistance (NTSR) or where the resistance mechanism is still undetermined. Rapid physiological assays using leaf tissue is a method that may increase the accuracy and speed of resistance confirmations, not require prior knowledge of the resistance mechanism, decrease cost of investigation compared to whole-plant studies, and potentially decrease the cost for farmers who seek to implement a weed control operation shortly after the failed weed control is reported in the field. Our research objective was to develop a rapid physiological assay for waterhemp (*Amaranthus tuberculatus)* that discerns both TSR and NTSR fomesafen-resistance from a fomesafen-susceptible population. Preliminary greenhouse and laboratory research experiments were conducted to evaluate and refine assay parameters, including: leaf disk diameter, culture plate type, supporting medium, herbicide concentration, incubation duration, and data collection methods. Waterhemp populations used to evaluate the assay included two known fomesafen-resistant populations carrying the ΔG210 and one known susceptible population. The established protocol consisted of excising 6-mm leaf disks from newly expanded tissue and placing them on an agar medium amended with fomesafen at a concentration of 100 µM. Leaf disks were incubated under controlled conditions until data collection. Chlorophyll fluorescence (Fv/Fm) were measured at 48 hours after treatment (HAT), while RGB images were collected at 72 HAT and analyzed using Turfgrass Analyzer to quantify the percentage of green coverage. In preliminary leaf disc assays, visual observations, Fv/Fm, and % green pixels each separated the PPO-inhibitor-resistant waterhemp populations from the susceptible population.

169 - AmaranthusDB: An Integrated Genomic Resource for Comparative Genomics in Amaranthus

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The genus *Amaranthus* includes some of the most damaging herbicide-resistant weeds in North American cropping systems, notably Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus*), as well as domesticated grain and vegetable crops. Although chromosome-level assemblies now exist for many *Amaranthus* species, genus-focused resources have not kept pace: the only accessible *Amaranthus* database is limited to population genetics of grain amaranths on a single reference genome, and broader weed genomics platforms are not designed for comparisons within the genus. We present AmaranthusDB, an integrated database of 43 genome assemblies from 12 weedy, cultivated, and wild species, built to let researchers move from a single gene to genus-wide patterns in a few steps. Users can search functionally annotated genes by identifier, description, Gene Ontology term, or pathway, open gene pages with structure, neighboring genes, and downloadable sequences, run BLAST, and view any region in an embedded JBrowse 2 genome browser. Comparative genomics is explored at three scales. Interactive dot plots display every collinear gene pair between two assemblies, can be filtered by chromosome, and let users click any block to inspect its genes. Ribbon-style synteny plots trace collinear blocks, inversions, and chromosomal rearrangements across multiple genomes, and a microsynteny viewer shows conserved gene order surrounding a gene of interest, allowing users to follow candidate loci such as herbicide targets or detoxification genes across species. An expression atlas presents curated RNA-sequencing experiments as interactive heat maps, allowing users to query one or many genes and compare expression across tissues, developmental stages, and stress treatments. Additional modules include a pangenome browser, a population diversity browser that reports diversity and differentiation statistics for grain amaranths and wild relatives, a trait browser linking published quantitative trait loci, association signals, and resistance genes to genomic positions, and resources for markers, germplasm, and bulk downloads. AmaranthusDB provides weed scientists with a single, extensible platform for connecting genes, genome structure, and expression across weedy and cultivated *Amaranthus* species.

170 - Screening for Glufosinate, 2,4-D, and Dicamba Resistance in Palmer Amaranth (*Amaranthus palmeri* S. Watson) in Nebraska

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Amaranthus palmeri S. Watson (Palmer amaranth) is a troublesome weed associated with economic losses in row crops, and herbicide-resistant populations are increasing across the United States. As a result of glyphosate resistance, management programs in Nebraska have shifted reliance to post-emergence applications of glufosinate and synthetic auxins, raising concerns about the selection pressure these

herbicides impose. Thus, this study monitored the evolution of resistance to glufosinate-L, 2,4-D, and dicamba in Nebraska’s Palmer amaranth. A greenhouse dose-response was conducted with 20 Palmer amaranth accessions from Nebraska. Recommended field rates were used as 1x doses: 370 g ai ha^{-1} for glufosinate-L, 1065 g ae ha^{-1} for 2,4-D, and 420 g ae ha^{-1} for dicamba. The doses for glufosinate were 1/320x, 1/160x, 1/8x, 1/4, 1x and 3x. For 2,4-D they were 1/32, 1/16, 1/8, 1/4, 1 and 3x and for dicamba they were 1/160, 1/32, 1/8, 1 and 3x. A single nozzle spray chamber equipped with DG9502EVS (glufosinate-L) and AI9502EVS (2,4-D and dicamba) was calibrated to deliver 140 L ha at 276 kPa with a traveling velocity of 1.35 m s^{-1} and was used to treat plants at 7.6 to12.7 cm height. Biomass was harvested 21 days after application, dried, and converted to biomass reduction percentage (BMR%), compared to the untreated checks. Data were fitted to LL.4 dose-response models and analyzed in R. The estimated ED_{95} for glufosinate-L was below 1x for all accessions, with only four higher than 1/4x. Conversely, only seven accessions had ED_{95} below 1x for 2,4-D and four below 1x for dicamba. Most concerning, accession 9 had BMR% at 3x ranging from 83 to 97% with 2,4-D and 80 to 97% with dicamba. Accession 26 ranged from 75 to 97% (2,4-D) and 81 to 97% (dicamba) at 3x. Results support that all accessions were susceptible to glufosinate-L but less so to 2,4-D and dicamba. These findings help understand this species’ context in Nebraska and emphasize the importance of alternating herbicides.

171 - Confirming Group 15 Herbicide Resistance in an IL Giant Foxtail Population

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A giant foxtail (*Setaria faberi*) population in Illinois was not controlled with S-metolachlor following several years of Group 15 herbicide use. Field experiments were established during 2024-2026 to determine the response of this population to various Group 15 herbicides. Bare ground experiments included four rates (0.5x, 1x, 2x, 4x, with the 1x being a label-recommended rate) of S-metolachlor, acetochlor, dimethenamid-P, and pyroxasulfone. In 2024, 2x and 4x rates of all Group 15 herbicides reduced giant foxtail density and biomass compared with the nontreated control, whereas each rate of pyroxasulfone reduced density and biomass compared to the nontreated. The 0.5x and 1x rates of acetochlor and dimenthenamid-P did not reduce density or biomass while the 1x rate of S-metolachlor reduced giant foxtail biomass but not density. The 2x and 4x rates of pyroxasulfone were the only treatments to provide at least 90% control 28 days after application. In 2025 no herbicide, regardless of rate, reduced giant foxtail density nor biomass compared with the nontreated control. No treatment provided greater than 70% control 28 days after application. In 2026, no treatments provided statistical differences in density compared with the nontreated control while the 4x rate of acetochlor was the only treatment to reduce biomass compared to the nontreated control. Accumulated rainfall within 28 days after application totaled 11 cm in 2024, 5 cm in 2025, and 6 cm in 2026. Greenhouse dose-response experiments were initiated to compare the response of the putative Group 15-resistant population to a known sensitive population. A 1.5x logarithmic herbicide rate structure was used for the sensitive population and a 2x logarithmic rate structure was used for the putative resistant population for S-metolachlor and dimethenamid-P. S-metolachlor GR_{50} values were 215 and 1,708 g ai ha^{-1}, whereas dimethenamid-P GR_{50} values were 69 and 279 g ai ha^{-1} for the sensitive and resistant populations,

respectively. Collectively, these field and greenhouse results demonstrate greatly reduced sensitivity of a giant foxtail population to Group 15 herbicides.

172 - Documenting the Extent of Resistance to Very-Long-Chain Fatty Acid Inhibitors in Waterhemp (*Amaranthus tuberculatus*) Populations across Illinois

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Waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] is one of the most competitive weed species in U.S. crop production and has evolved resistance to herbicides across eight sites of action, including very-long-chain fatty acid (VLCFA) inhibitors. VLCFA-inhibiting herbicides, such as *S*-metolachlor, are critical components of residual weed control programs for managing grass and small-seeded broadleaf weeds, including waterhemp. Two Illinois waterhemp populations were previously reported resistant to *S*-metolachlor via enhanced herbicide metabolism. Growing concerns among farmers about the reduced efficacy of *S*-metolachlor to control waterhemp led us to conduct this study. The objectives of this study were to 1) document the extent of *S*-metolachlor resistance in waterhemp populations across Illinois and 2) evaluate cross-resistance to other Group 15 herbicides, acetochlor and pyroxasulfone. Waterhemp populations were collected from 127 locations across Illinois in fall 2023 and were supplemented with public submissions and previously characterized resistant (CHR, SID) and susceptible (WUS) populations, yielding a total of 240 contemporary populations. Additionally, 39 populations collected about two decades ago (2003-2008) were used for comparison with contemporary populations. All contemporary populations were screened with 0.4 and 0.8 kg ai ha^{-1} of *S*-metolachlor, and the old populations at a single rate of 0.8 kg ai ha^{-1}. Waterhemp emergence and stunting percentage were recorded 21 days after herbicide treatment. Subsequent dose-response experiments were conducted to i) compare six contemporary populations, with varied level of sensitivity to *S*-metolachlor, against two old populations, and WUS to evaluate the level of *S*-metolachlor resistance and ii) evaluate cross-resistance to acetochlor and pyroxasulfone in three *S*-metolachlor resistant contemporary populations. Statewide screening showed that resistance to *S*-metolachlor in waterhemp is widespread across Illinois, with 41 of 240 contemporary populations having a greater survival percentage than the previously characterized resistant populations CHR (42%) and SID (50%) at 0.8 kg ai ha^{-1} of *S*-metolachlor. All but one population from the old collection was completely controlled at 0.8 kg ai ha^{-1} of *S*-metolachlor. Dose-response experiments revealed up to 53-fold resistance in contemporary populations as compared to WUS, based on LD_{50} estimates. All three contemporary populations tested were found cross-resistant to acetochlor (40- to 60-fold) and pyroxasulfone (5- to 27-fold), based on GR_{50} estimates. In conclusion, waterhemp populations across Illinois exhibit a very wide range of sensitivity to *S*-metolachlor. Rapidly evolving Group 15 herbicide resistance leaves farmers with increasingly fewer weed control options. Future work

will use a genome-wide association study to identify genomic regions associated with *S*-metolachlor resistance in waterhemp.

NCWSS Student Paper Contest - Herbicide Applications for Weed Management - Session 1

174 - Influence of Tank-Mix Partners and Spray Solution pH on Encapsulated Saflufenacil + Pyroxasulfone Injury in Corn

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[1]University of Missouri

Saflufenacil is a protoporphyrinogen oxidase (PPO) inhibiting herbicide with residual and post-emergent (POST) activity that controls several important large-seeded broadleaf weeds occurring in corn. Although injurious to corn, saflufenacil has recently been encapsulated, along with pyroxasulfone, and labeled for use POST in corn up to the V3 growth stage. However, corn injury following tank mixing of encapsulated saflufenacil + pyroxasulfone (S+P) with standard partners remains possible. Repeated field experiments near Columbia, MO were conducted during the 2026 growing season to assess corn injury from encapsulated S + P using mixtures with common corn herbicides (atrazine, glufosinate, glyphosate, topramezone) at variable spray solution pH's (5.2, 6.5, 7.7,9.0) for a total of 16 treatments plus a control. The experiment was set up in a randomized complete block design with 4 replications. Corn was sprayed at the V2 growth stage using a CO2 pressurized backpack sprayer at 140 L ha^{-1} in 3.0 by 7.6 m plots. Visual injury ratings were taken at 4, 7, and 14 days after treatment (DAT), along with corn biomass collected at 7 and 14 DAT to measure corn response. Encapsulated S + P tank-mixed with glufosinate or glyphosate or sprayed at a solution pH of 9.0 resulted in up to 20% visual injury at 4 DAT. Visual injury declined at each successive rating and by 14 DAT no treatment exhibited greater than 4% injury. Additionally, no treatment impacted biomass accumulation at 7 or 14 DAT. Results indicate that while low levels of corn injury may occur following encapsulated S + P application, plants quickly recover with no lasting impact.

175 - Investigating the Impact of Glufosinate Tank Mixtures on Soybean Injury and Yield

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Best management practices recommend tank mixing multiple herbicides for more robust weed management. A commercial challenge is that glufosinate applications in glufosinate-resistant soybean are restricted by the glufosinate product labels to the vegetative growth of soybeans. Applications of glufosinate during reproductive development of soybean have been implicated to increase the risk of elevated herbicide residues in the soybean grain or reductions in grain yield. Furthermore, the combination of glufosinate with other herbicides and the use of multiple adjuvant products may exacerbate concerns for a negative soybean response. Therefore in 2025 and 2026, field experiments were conducted in seven states (AR, IN, KS, MI, MO, ND, TN) to investigate how tank mixtures with glufosinate and commonly used herbicides or adjuvants for late postemergence applications in soybean production impact both crop injury and grain yield. Glufosinate was applied at two soybean growth stages (V5/V6, R2) with different combinations of glyphosate, 2,4-D choline, clethodim, s-metolachlor, pyroxasulfone, acetochlor, ammonium sulfate (AMS) and methylated seed oil (MSO). Pooled across locations from 2025, there was no significant ($p > 0.05$) interaction between application timing and tank mixture on visual injury at 3, 7, 14, 21, or 28 DAT. However, application timing and tank mixture independently significantly ($p < 0.01$) impacted visual injury at all rating intervals. Visual estimates of injury 7 DAT averaged 10% after the V5/V6 application and 5% after the R2 application. Regardless of application timing, soybean injury was greatest, up to 15%, when glufosinate + glyphosate + 2,4-D choline + s-metolachlor were applied with 1% v/v MSO and 2.5% v/v AMS. Additionally, these tank mixtures with glufosinate impacted soybean grain yield, but no herbicide mixture had a mean yield less than the nontreated or glufosinate alone. These results indicate a substantial level of soybean tolerance to late glufosinate applications exist in terms of a grain yield response. However, a more complete analysis of the soybean harvest index data and the 2026 yield data need to be conducted, as well as consideration of the glufosinate product labels that do not allow for applications during reproductive growth due to potential herbicide residues in the grain.

176 - Shattercane (*Sorghum bicolor* ssp. *drummondii*) Seed Production Following Late-Season Herbicide Applications in Corn

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[1]University of Missouri

Shattercane (*Sorghum bicolor* subsp. *drummondii*) is a competitive annual grass weed in corn (*Zea mays* L.). Viable seed production by shattercane is increasingly observed in Missouri corn fields, presenting challenges for long-term management. Late-season herbicide applications may provide an opportunity to reduce viable seed production and limit subsequent additions to the soil seedbank. Field experiments were conducted in central Missouri during 2025 and 2026 using 2,4-D-tolerant corn to evaluate the effects of herbicide rate and application method on shattercane seed production and viability. Glyphosate (1.031 and 2.061 kg ai ha^{-1}) and quizalofop-P-ethyl (0.046 and 0.092 kg ai ha^{-1}) were applied using either a simulated ground sprayer or an unmanned aerial vehicle (UAV) in a randomized complete block design on plots 3 m by 13.7 m. Applications targeted established shattercane plants after pollen shed but before physiological seed maturity, when corn was at the VT to R1 growth stages. Visual injury was assessed weekly from 1 to 4 weeks after treatment (WAT). Panicles were collected from six plants per plot over a six-week period, beginning at 1 WAT and continuing until seedhead production ceased. Seed production was estimated

from the total weight of collected seeds and the weight of 200-seed subsamples, while viability was determined using tetrazolium (TZ) testing. Untreated seed viability averaged 93%. At the higher quizalofop rate, viability averaged 26% following ground application and 58% following UAV application, compared with 40% and 45%, respectively, for high-rate glyphosate. Despite lower seed viability on primary seedheads following high-rate quizalofop treatments, surviving plants continued producing additional tillers and seedheads. In contrast, high-rate glyphosate resulted in greater plant mortality, limiting subsequent seed production. These findings suggest that late-season herbicide applications of quizalofop and glyphosate may offer opportunities for limiting shattercane seedbank replenishment.

177 - A Greenhouse Evaluation of Jack O'Lantern Pumpkin Tolerance to a Five-Way Herbicide Mixture

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Pumpkin (*Cucurbita pepo L.*) growers have few herbicide options, and no single registered product controls the full spectrum of weeds that occur in production fields. Tank-mixing multiple residual herbicides with different modes of action could broaden weed control and reduce the number of applications, but crop tolerance to multi-product mixtures is largely unknown and could limit their adoption. This study was designed to evaluate the tolerance of Jack-o'-lantern pumpkin to a five-way herbicide mixture and to its individual components. Greenhouse trials were conducted in 2026 at the Purdue University Horticulture Plant Growth Facility, West Lafayette, IN. Pumpkin seeds were planted 2 cm deep in 15 cm diameter pots filled with 1:1 (v/v) mixture of sand and BM7 potting substrate. Treatments were applied on the day of planting using a laboratory spray chamber equipped with a single TeeJet 8002 EVS flat-fan nozzle calibrated to deliver 187 L ha^{-1} at 207 kPa. Treatments consisted of an untreated check; fomesafen (280 g ai ha^{-1}); *S*-metolachlor (1,470 g ai ha^{-1}); halosulfuron-methyl (39.4 g ai ha^{-1}); a two-way mixture of clomazone (213 g ai ha^{-1}) plus ethalfluralin (676 g ai ha^{-1}); and a five-way mixture of clomazone, ethalfluralin, fomesafen, *S*-metolachlor, and halosulfuron-methyl at the same rates. The experiment was conducted in two experimental runs, with four replications per treatment in a completely randomized block design. Data collected included visual injury at 3 weeks after treatment (WAT), leaf number, leaf area, plant height, and dry weight of aboveground biomass. Growth variables were expressed as a percentage of the untreated check. Data were subjected to ANOVA with treatment and run as factors, and means were separated using Tukey's HSD ($\alpha = 0.05$). Run and the treatment-by-run interaction were not significant for any data; therefore, all data were pooled across both runs. At 3 WAT, treatment significantly affected visual injury ($P = 0.028$), leaf number ($P = 0.010$), leaf area ($P < 0.001$), plant height ($P = 0.004$), and dry weight ($P = 0.004$). The five-way mixture caused the greatest injury (29%), while *S*-metolachlor caused the least (3%). Relative to the untreated check, the five-way mixture reduced leaf area (50%), plant height (49%) and dry weight (49%). Halosulfuron-methyl alone also reduced leaf area (38%) and dry weight (46%) compared with the check, whereas fomesafen, *S*-metolachlor, and clomazone plus ethalfluralin, did not differ significantly from the untreated check for any growth data. In conclusion, Jack- o'-lantern' pumpkin tolerated fomesafen, *S*-metolachlor, and clomazone plus ethalfluralin, but the five-way mixture caused significant injury and growth reduction.

178 - Weathering the Variability: Diflufenican Efficacy and Waterhemp (Amaranthus tuberculatus) Management Across Growing Seasons

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Increasing herbicide resistance in waterhemp (*Amaranthus tuberculatus* (Moq.) J.D. Sauer) underscores the need for additional herbicide sites of action and effective soil residual herbicides. Diflufenican (DFF), a Group 12 phytoene desaturase inhibitor, will be commercially available in 2027 for U.S. corn and soybean production sold as Convintro™. However, soybean tolerance and weed control may vary with herbicide mixtures, tillage, planting date, and environmental conditions. Field experiments were conducted in 2025 and 2026 in Belleville, Illinois, to evaluate these factors and interactions. Treatments were arranged in a 2 × 2 × 9 factorial with four replications, including tillage system (conventional; no-till), planting date (early; late), and nine herbicide treatments. Preemergence (PRE) treatments included (1) DFF (149 g ai ha^{-1}) alone, or combined with the following active ingredients and rates: (2) metribuzin (280 g ai ha^{-1}); (3) flumioxazin (87.4 g ai ha^{-1}); (4) [flumioxazin (87.9 g ai ha^{-1}) + pyroxasulfone (111.6 g ai ha^{-1})]; (5) [flumioxazin (87.7 g ai ha^{-1}) + pyroxasulfone (112.1 g ai ha^{-1}) + metribuzin (263.1 g ai ha^{-1})]; (6) acetochlor (1,267 g ai ha^{-1}); (7) flumioxazin (87.4 g ai ha^{-1}) + metribuzin (280 g ai ha^{-1}); (8) acetochlor (1,267 g ai ha^{-1}) + metribuzin (280 g ai ha^{-1}); and (9) nontreated check. Soybean injury and weed control were visually evaluated at 7, 14, and 21 days after emergence (DAE). Weed density, weed biomass, and soybean stand were recorded at 21 DAE. Soybean yield was measured at harvest. Waterhemp control ranged from 95 to 99% across DFF-containing herbicide programs. Total weed biomass was affected by herbicide program ($P<0.001$); in both years, all programs except DFF alone reduced biomass compared to the nontreated check. Overall soybean injury, including bleaching and stunting, was greatest in 2025 when late-planted soybeans received 1.4 cm of rainfall shortly after soybean emergence, coinciding with 39-74% injury at 7 DAE in tilled plots compared with 15-17% in other tillage by planting date combinations ($P<0.001$), and soybean injury was no longer evident by 21 DAE. In 2026, limited immediate postemergence rainfall coincided with injury of 1% or less, and despite adequate rainfall, no additional injury presented after 7 DAE. In 2026, soybean stand was significantly reduced in the early planting date, especially in a no-till environment ($P=0.021$). However, early-planted soybeans yielded more than late-planted in both years ($P=0.001$). These findings indicate that DFF-containing PRE programs provided waterhemp control, while weed biomass and soybean injury varied with tillage system and by year. Soybean injury may be more strongly influenced by rainfall quantity and timing than by planting date, though tillage system could also affect injury severity under certain conditions. Herbicide tank mixtures improved broad-spectrum weed control, while herbicide-related yield reductions were not detected.

179 - The Efficacy of Corn Premix Programs and Application Timing with Reduced Atrazine Applications

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Atrazine is the most commonly applied herbicide in United States corn production, where it is used for pre and post-emergence control of broadleaf and grass weeds. It is a controversial product due to its potential for off-target movement into groundwater systems via irrigation, resulting in potential regulatory restrictions from the EPA. While atrazine free premixes have become more common due to their ease of use and efficacy in preemergence (PRE) and postemergence (POST) applications, they are frequently applied alongside atrazine, and more work is needed to determine the efficacy of atrazine in these programs. The objective of this project is to evaluate herbicide programs consisting of two factors, five commercially available premixes (SMPB - S-metolachlor, mesotrione, pyroxasulfone, bicyclopyrone; PS - pyroxasulfone, saflufenacil; FIT - flufenacet, isoxaflutole, thiencarbazone-methyl; MCP - mesotrione, clopyralid, pyroxasulfone and AMC - acetochlor, mesotrione, clopyralid) and three atrazine application timings (PRE, POST, none). This was a fully factorial randomized complete block design with 15 herbicide programs, an untreated control, and 4 replications. The site was located at the Western Agricultural Research Station in South Charleston, Ohio and was replicated over two growing seasons. Applications were made with a CO2 pressurized backpack sprayer and a handheld boom. POST applications were applied to all plots with glyphosate + liquid ammonium sulfate, the premix, and atrazine where applicable. Data collection consisted of visual evaluations of herbicide efficacy (% control) and crop injury (% injured) 14 and 28 days after treatment (DAT) or emergence (DAE), respectively, and at the time of the POST application. Weed density (count 0.5m-2) was measured 14 and 28 DAT and at POST, and weed biomass (g 0.5m-2) at final POST. Corn stand was measured at V2, and yield was collected at the end of the season. Species evaluated primarily consisted of giant foxtail (Setaria faberi Herrm.), giant ragweed (Ambrosia trifida L.), velvetleaf (Abutilon theophrasti Medik.), and common lambsquarters (Chenopodium album L.). Data was analyzed in SAS 9.4 using the GLIMMIX procedure. The global F-test was used to evaluate significance. Treatment means were separated using P values for differences of least significant means at $\alpha \leq 0.05$. In 2025 PRE applications, atrazine timing was significant only for giant foxtail at 14 DAT. At 28 DAT, PS had the lowest overall control for giant foxtail, giant ragweed, and velvetleaf and less control than FIT and AMC for common lambsquarters. For 28 DA POST applications in 2025 and 2026, common lambsquarters and velvetleaf were controlled by all treatments, and there was no difference in giant foxtail control. In 2026 at 28 DAT PRE, preemergence atrazine timing had better giant ragweed control than no atrazine treatments, and PS had the lowest control overall. Premix did not influence velvetleaf or common lambsquarters control. For giant foxtail, PS had less control than SMPB and AMC. For 28 DA POST application giant ragweed control, premixes formed three groups with SMPB+MCP+AMC having greater control than PS, which had greater control than FIT. For yield, atrazine application timing and premix were not significant in either year.

180 - Soybean Herbicide Strategies for Management of a Waterhemp (*Amaranthus tuberculatus*) Population Resistant to Glufosinate and Multiple Other Herbicide Groups

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Waterhemp (*Amaranthus tuberculatus*) management has become a major challenge in soybean (*Glycine max*) production systems due to the development of resistance evolved to multiple herbicide modes of action within a single population. In some instances, the combination of herbicide resistance for individual plants within a field population may impact every postemergence herbicide available. A field population from Montgomery County, Indiana contains individual waterhemp plants that have survived foliar applications of 1X or greater labeled rates of glyphosate, fomesafen, 2,4-D choline, and glufosinate. Problematic waterhemp populations such as this require integrated herbicide strategies since no single postemergence herbicide can provide complete waterhemp control. The objective of our field experiment was to determine the efficacy of several strategies and multiple application timings on a waterhemp field population with resistance to multiple herbicide mode of action groups. The field experiment was established as a randomized complete block design with four replications in 2025 and 2026. A standard preemergence (PRE) herbicide was applied for most treatments but was different between years. Residual waterhemp control at the time of the POST application was approximately 65% in 2025 (cloransulam (48 g ae ha^{-1}) + sulfentrazone (372 g ai ha^{-1})) and nearly 90% in 2026 (flumioxazin (52.65 g ai ha^{-1}) + metribuzin (157.95 g ai ha^{-1}) + pyroxasulfone (67.39 g ai ha^{-1})). The relatively lower level of residual weed control in 2025 required two POST sequential applications containing glufosinate (337 g ae ha^{-1}), or combinations of glufosinate with 2,4-D Choline (1065 g ae ha^{-1}) and glyphosate (926 g ae ha^{-1}) to achieve greater than 95% waterhemp control through the end of July. In 2026 extensive soil residual control of waterhemp resulting from the PRE herbicide application translated to 95% or greater control of waterhemp following the POST applications, regardless of the specific herbicide actives or mixtures glyphosate, 2,4-D choline, glufosinate, and fomesafen. Effective management of this multiple-resistant waterhemp population was largely dependent on an effective soil residual herbicide applied at soybean planting.

181 - Evaluating Two-Way Tank Mixes for Postemergence Control of Herbicide-Resistant Waterhemp (*Amaranthus tuberculatus*) in Current and Future Soybean Production Systems

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The proliferation of herbicide-resistant waterhemp (*Amaranthus tuberculatus* Moq.) populations, including resistance to multiple sites of action, combined with new developments in soybean (*Glycine max* L.) herbicide resistance traits has and will continue to alter the soybean chemical weed control

landscape. The combination of multiple foliar herbicides in one postemergence (POST) application can increase weed control and delay development of herbicide resistance, but new developments warrant reevaluation of effective POST tank-mixture options. The objective of this study was to investigate whether two-way active ingredient combinations are consistently more effective than single active ingredient solutions and to evaluate which herbicide programs provide effective (>85% mortality and biomass reduction) POST control of herbicide-resistant waterhemp. The study evaluated herbicides currently labeled in soybean and herbicides that will become labeled through novel traits (e.g., mesotrione on Vyconic soybean) in the future. A greenhouse experiment was conducted following a factorial design of sixty-six herbicide treatments and three waterhemp accessions (i.e., 66x3). Herbicide treatments contained eleven active ingredients from seven sites of action (Group 2: chlorimuron, cloransulam, imazethapyr; Group 4; 2,4-D, dicamba; Group 6: bentazon; Group 9: glyphosate; Group 10: glufosinate; Group 14: fomesafen, lactofen; Group 27: mesotrione) applied at label rates and all two-way active ingredient mixtures. Waterhemp accessions studied included A106, A125, and A133, collected from different locations in Wisconsin and chosen due to variation in herbicide resistance profiles. Treatments were applied when average waterhemp plant height was 10 cm using a research spray chamber calibrated to deliver 140 L ha^{-1} with an AI09502 nozzle. Twenty-one days after treatment (DAT), mortality data were recorded; plants were harvested and dried to constant weight to obtain biomass data. Mortality and biomass reduction were estimated across populations to determine treatment efficacy across a variety of waterhemp resistance profiles. A field experiment was conducted to validate preliminary greenhouse results following a randomized complete block design with four replications in 2026 at two locations, Brooklyn, WI (confirmed 2,4-D-, glyphosate-, fomesafen, and mesotrione -resistant waterhemp) and Lancaster, WI (confirmed glyphosate-resistant waterhemp). Field herbicide treatments contained five active ingredients from five sites of action (2,4-D, glyphosate, glufosinate, fomesafen, mesotrione) applied alone and all two-way active ingredient mixtures at label rates with the addition of ammonium sulfate (2.24 kg ha^{-1}) and crop oil concentrate (1% V/V). Treatments were applied when average waterhemp height was 10 cm using a backpack sprayer calibrated to deliver 140 L ha^{-1} with an AIXR 110015 nozzle. Twenty-one DAT waterhemp plants were harvested and dried to constant weight to estimate biomass reduction. Six of sixty-six treatments evaluated in the greenhouse provided effective control of waterhemp (≥85% mortality and biomass reduction) and were all two-way active ingredient mixes containing either glufosinate or 2,4-D. Two of fifteen treatments evaluated in the field provided effective control (≥85% biomass reduction) of waterhemp in both locations (glufosinate + mesotrione, glufosinate + 2,4-D). This study emphasizes the importance of glufosinate and the limited effective POST chemical weed control programs for waterhemp management in soybean cropping systems based on both current and novel herbicide resistance traits.

182 - Investigating Asian Copperleaf Control in Corn with Pre- and Post-Emergence Herbicides

Rocco D'Antico[1], Meaghan Anderson[1], Wesley Everman[1], Damian Franzenburg[1], Iththiphonh Alex Macvilay[1], Estefania Gomiero Polli[1], Tunde Akanbi[1], Caroline Wayhs Backes[1], Steven Tri[1]

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Asian copperleaf (*Acalypha australis*) is a newly arising weedy species identified in crop fields of Illinois, Iowa, and Minnesota. This spurge species, originating from southeast Asia, was first discovered in an Iowan corn field near Cedar Falls in 2016. In its native range, select populations have been documented as resistant to Group 2 ALS, Group 9 Glyphosate, and Group 14 PPOs. Thus, characterizing this species' response to common midwestern herbicide treatments is vital to controlling its spread and mitigating its damage. This study separated pre-emergence applications, post-emergence applications, and a combined pre- and post- program (one application at each) into individual experiments. These were arranged as in-field, randomized plot (3.0m by 7.6m size) designs with four replications; all experiments shared an in-production corn (*Zea mays*) field outside of Independence, Iowa, United States. Seven individual pre-emergence products, plus a non-treated check, were applied on 5/7/2026 and evaluated 28, 35, and 42 days after application (DAA). Similarly, nine post-emergence products, plus a non-treated check, were applied on 6/18/2026 and evaluated 7, 14, 21, and 28 DAA. Additionally, the combined program applied pre-emergence treatments on 5/15/26 and post-emergence on 6/18/2026 (35 DAA1), then evaluated 21, 28, 35, 42, 49, 56, and 63 DAA1. Four pre-emergence pre-mixes were applied initially, all followed post-emergence by glufosinate. Applied pre-emergence, atrazine, mesotrione, and s-metolachlor demonstrated the lowest (25.0%, 10.0%, and 15.0% control @ 28 DAA, respectively) control of Asian copperleaf. Isoxaflutole and saflufenacil demonstrated satisfactory (48.8% and 51.3%) inhibition, with acetochlor providing the best (65.0%). Applied post-emergence, atrazine, interestingly, provides explementary control (93.8% @ 14 DAA), along with glyphosate and glufosinate (87.5% and 83.8%). Carfentrazone and topramezone initially promised potential (37.5% and 36.3% @ 7 DAA) control, however, decreased significantly (15% and 2.5% @ 28 DAA) after 14 days. Separately, all four combined pre- and post-emergence programs demonstrated prolonged efficacy (>90% @ 63 DAA1). These combined programs all provided significantly (p-value < 0.0001) better control over individual pre- or post- treatments. This research serves as an important benchmark for Asian copperleaf control as it first appears in the region. And, it demonstrates the significance of season-long management programs. Subsequent studies may seek to identify or reject homogeneity among populations, and the influence herbicide treatment has on seeds spread.

183 - Stakeholder Perceptions of Mesotrione Use and Stewardship in Vyconic™ Soybean Technology

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Herbicide-resistant weeds challenge and limit effective soybean weed management programs. Vyconic™ soybean technology combines tolerance to multiple herbicides, including mesotrione, providing growers with additional weed management options, pending regulatory approvals. Yet, increased use of mesotrione in soybean may intensify selection pressure for resistance to 4-hydroxyphenylpyruvate dioxygenase (HPPD)-inhibiting herbicides across corn-soybean rotations. The objective of this survey was to assess stakeholder expectations regarding adoption of Vyconic™ soybean technology upon its commercial release, anticipated mesotrione use patterns in soybean, weed species that would motivate growers to use mesotrione, and stewardship of HPPD-inhibitor herbicides. An online survey targeting farmers, crop consultants, agronomists, agricultural retailers, researchers, industry representatives, and

other stakeholders involved in U.S. soybean production and weed management was conducted using the Qualtrics platform from May through September 2026. The survey link was distributed through email lists, crop management newsletters, professional networks, social media platforms, and via QR codes presented at Extension events. The survey included 11 questions organized into four sections: respondent demographics and operational characteristics, familiarity with and anticipated adoption of Vyconic™ soybean technology, anticipated mesotrione application practices and target weed species, and perceived opportunities and stewardship concerns associated with the technology. A total of 334 valid responses were obtained. Quantitative data were summarized using descriptive statistics, and open-ended responses were analyzed using thematic coding to identify recurrent reported perceived benefits and concerns. Respondents represented 43 U.S. states, with the greatest number of responses (46%) coming from Wisconsin, Illinois, Iowa, and Minnesota. Sixty-six percent of respondents indicated that they are very likely or somewhat likely to adopt or recommend Vyconic soybean technology upon its commercial release, whereas 24% are unsure and 11% are unlikely to do so. Among respondents asked about anticipated mesotrione application timing (n=298), 24% expect to use mesotrione primarily PRE, 19% primarily POST, and 24% in both PRE and POST applications; 19% are unlikely to use mesotrione, and 14% are unsure. Of those who expect to use mesotrione in Vyconic™ soybean (n=241), 77% expect to apply mesotrione mainly in a tank mixture with other herbicides, 16% expect to apply mesotrione both standalone and in a tank mixture, and 1% expect to use mesotrione mainly standalone. When asked which weed species would motivate mesotrione use in Vyconic™ soybean, waterhemp (*Amaranthus tuberculatus*) was the most frequently selected target weed species (84%), followed by giant ragweed (*Ambrosia trifida*; 51%), Palmer amaranth (*Amaranthus palmeri*; 42%), and common lambsquarters (*Chenopodium album*; 38%). Most respondents who answered the stewardship question (n=241) are moderately to very concerned about weeds developing resistance to HPPD-inhibiting herbicides (92%). Open-ended responses commonly identified benefits such as increased weed management flexibility, waterhemp control, and reduced concern about mesotrione carryover from corn. Conversely, respondents expressed concerns regarding mesotrione overuse, repeated HPPD-inhibitor selection across corn and soybean rotations, and the potential loss of mesotrione effectiveness. These results demonstrate strong stakeholder interest in Vyconic soybean technology while emphasizing the importance of diversified herbicide use patterns and proactive stewardship practices across crop rotations to maintain the long-term utility of mesotrione and other HPPD-inhibiting herbicides.

184 - Comparison of Fall and Spring Applied Pyroxasulfone and Flumioxazin for Waterhemp (*Amaranthus tuberculatus*) Control

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Waterhemp (*Amaranthus tuberculatus*) continues to be a problematic weed in row crop systems across the Midwest. Preemergence herbicides have been relied on more in recent years as a method of reducing pressure for postemergence herbicide applications. It is increasingly common in North Dakota to apply herbicides in late fall to control early emerging summer annual weeds like kochia (*Bassia scoparia*) and wild oat (*Avena fatua*). The increased popularity of this practice has led to questions about the utility of

this application timing to control later emerging summer annual weeds like waterhemp. The objective of this research was to compare fall, spring, or fall followed by spring application of residual herbicides for waterhemp control. The experimental design was a RCBD with treatments arranged in a factorial treatment structure. Factor A consisted of fall applications: no herbicide, pyroxasulfone applied at 119 g ha-1, or flumioxazin applied at 105 g ha-1. Factor B was spring application that consisted of: no herbicide, pyroxasulfone applied at 119 g ha-1, or flumioxazin applied at 105 g ha-1. Trial locations were in Fargo ND, Volga SD, Rosemount MN, and Brooklyn WI. Fall treatments were applied in late October or early November, and spring treatments were applied at soybean planting in mid to late May. Waterhemp control was evaluated at 0, 2, 4, and 6 weeks after soybean planting. After initial evaluation in the spring, trials were either tilled (SD and MN) or received a burndown without residual herbicide (ND and WI) to remove emerged waterhemp. Waterhemp control was also evaluated at soybean harvest in ND and SD. Data were analyzed in SAS using Fisher’s protected LSD of α=0.05. Site years were analyzed separately due to significant site by treatment interaction. Fall application of either herbicide in SD and MN resulted in fewer weeds present at planting compared to nontreated check. There were no treatment differences in WI at planting. There were no weeds present in ND at planting. Fall applied pyroxasulfone provided greater than 90% waterhemp control six weeks after planting in ND and SD, and 75% control in MN at the same evaluation timing. There was an interaction between fall and spring applications in MN and SD. At these sites fall pyroxasulfone followed by spring flumioxazin resulted in 94% or greater control. Fall application did not influence waterhemp control in WI, but spring applied flumioxazin provided 80% control six weeks after planting. In MN fall applied pyroxasulfone followed by spring applied flumioxazin resulted in the least amount of waterhemp plants and biomass at six weeks after planting. All treatment combinations resulted in similar reduction of density compared to no herbicide in ND and SD. Spring applied flumioxazin reduced waterhemp density and biomass in WI, while fall applications did not influence those measurements. Fall applications of pyroxasulfone resulted in the greatest soybean yield in ND, whereas fall pyroxasulfone, spring pyroxasulfone, and spring flumioxazin provided greatest yields in SD. These trials indicate that fall applied pyroxasulfone provides control of waterhemp in ND, SD, and MN.

185 - Post-Emergence Tank-Mixtures for Broadleaf Weed Control in Future Soybean Technologies

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Waterhemp (*Amaranthus tuberculatus*) and Kochia (*Bassia scoparia*) are the most problematic weeds in soybean (*Glycine max*) fields throughout the Northern Great Plains. With resistance to at least eight and five herbicide sites of actions respectively, future soybean technologies will implement mesotrione into POST applied mixtures to combat increasing resistant populations. The objective of this research was to evaluate different POST applied tank-mixtures for broadleaf weed control across five soybean regions in North Dakota for use in future soybean technologies. Five bare-ground field experiments were conducted during the 2026 growing season across North Dakota: Fargo, Rogers, Carrington, Minot, and Hettinger. Trials were a randomized complete block design (RCBD) with 4 replications at Fargo, Hettinger, and Carrington and 3 replications at Rogers and Minot. Treatments were arranged in a factorial structure, with

4 different herbicides applied at either a 0X or 1X proposed rate for this geography, resulting in 16 different treatment combinations. Herbicides evaluated were glufosinate-P-ammonium at 340 g ae ha^{-1}, 2,4-D at 1065 g ae ha^{-1}, dicamba at 560 g ae ha^{-1}, and mesotrione at 105 g ai ha^{-1}. Standard adjuvant packages were used where needed. Visible weed control was evaluated 7, 14, 21, and 28 days after treatment (DAT) on a 100% scale (0 = no weed control and 100 = complete plant death). Weed densities were recorded with two separate 0.5m^2 quadrats 28 DAT, with a biomass collection. In Fargo, treatments containing 2,4-D in the absence of dicamba, and the treatment with all herbicides had the best visible waterhemp control 14 DAT. All treatments reduced waterhemp density and biomass compared to the check. In Rogers, the treatment with glufosinate, 2,4-D, and mesotrione had the best visible control 14 DAT. Carrington generally had better weed control from treatments containing glufosinate than treatments without. In Minot, treatments containing glufosinate and another active ingredient generally had the best visible control of kochia, while 2,4-D alone had the worst. Similarly, all herbicides, except 2,4-D alone, reduced kochia density. All treatments at Minot reduced biomass when compared to the check. Hettinger had the greatest visible kochia control by treatments containing glufosinate with 2,4-D, mesotrione, or both. Across all locations, tank-mix treatments resulted in greater control than stand-alone active ingredients. While mesotrione alone did not provide exceptional control of waterhemp and kochia, it did provide an added benefit to current POST strategies.

NEWSS Student Contest Papers - Ph.D.

186 - Herbicide-Resistant Waterhemp (*Amaranthus tuberculatus*) in New York: Current Status and Alternative Herbicide Options for Management

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Waterhemp (*Amaranthus tuberculatus L.*) has become a serious weed problem for producers in the northeastern U.S., including New York (NY). Resistance to glyphosate has recently been reported among waterhemp populations from NY. A recent statewide survey further revealed putative resistance to multiple herbicide sites of action (SOA) among waterhemp populations and warrants effective alternative herbicide strategies for their control. The objectives of this research were to (1) confirm and characterize multiple resistance to glyphosate, atrazine, mesotrione, and chlorimuron/thifensulfuron among four selected NY waterhemp populations, and (2) evaluate the effectiveness of preemergence (PRE) followed by (*fb*) postemergence (POST) herbicides for control of multiple herbicide-resistant (MHR) waterhemp in Enlist soybeans. For objective 1, dose-response studies were conducted in a greenhouse at Cornell University Gutterman Bioclimatic Laboratory, Ithaca, NY to evaluate four selected waterhemp populations for multiple resistance to glyphosate, atrazine, mesotrione, and chlorimuron/thifensulfuron in comparison to a known susceptible population from Nebraska (NE). Seedlings of selected populations were grown in plastic pots (10 cm-diam) and young seedlings (7 to 10 cm) were treated with various doses of each herbicide. For objective 2, three field experiments were conducted in 2025 and 2026 on a

grower's field in Seneca and Tompkins Counties, NY to evaluate alternative PRE followed by (*fb)* POST herbicide programs for control of MHR waterhemp. Total nine herbicide programs along with nontreated weedy check were evaluated in a randomized complete block design with 4 replications. Results from greenhouse study indicated that all four NY waterhemp populations exhibited multiple resistance ranging from 2- to 23-fold to glyphosate, 6-to 36-fold to atrazine, 1.3- to 14-fold to mesotrione, and 7- to 10-fold to chlorimuron/thifensulfuron compared with NE population. In field study, all PRE herbicides, including tank mixture of metribuzin with chlorimuron, flumioxazin, *S*-metolachlor, or *S*-metolachlor plus cloransulam, as well as pyroxasulfone and sulfentrazone *fb* glufosinate + 2,4-D applied POST provided effective control (≥ 99%) and reduced shoot dry biomass (≥ 98%) of MHR waterhemp. In contrast, glyphosate alone provided only 62% control. In conclusions, these results confirm the first report of waterhemp populations from NY with multiple resistance to glyphosate, atrazine, mesotrione, and chlorimuron/thifensulfuron. Effective PRE *fb* POST herbicide programs tested in this research can provide effective, season-long control of MHR waterhemp.

187 - Evaluating Spray Coverage for Unmanned Aerial System-Applied Preemergence Herbicides in Edamame (*Glycine max* (L.) Merr.).

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Unmanned aerial systems (UAS) are increasingly used for herbicide applications, but their limited tank capacity favors low carrier volumes. Although UAS herbicide applications have been studied more extensively for postemergence (POST) use, comparatively less research has examined how carrier volume affects soil-surface coverage, preemergence (PRE) herbicide efficacy, and the minimum coverage required for effective weed suppression. This knowledge gap is particularly relevant to crops such as edamame (*Glycine max* (L.) Merr.), where limited POST herbicide options make effective PRE weed control critical. Field experiments were conducted at Virginia Tech's Eastern Shore Agricultural Research and Extension Center, Painter, Virginia, in 2024 and 2026 to evaluate UAS carrier volume, spray coverage, weed suppression, and crop response, and to identify the lowest coverage associated with weed control not significantly different from conventional ground application. S-metolachlor was applied at the labeled rate (1.42 kg a.i. per hectare) one day after edamame planting using a UAS at seven carrier volumes ranging from 2 to 8 gallons per acre (GPA; 18.7-74.8 liters per hectare; LPH), with 1 GPA increments. A conventional backpack sprayer at 15 GPA (140.3 LPH) and a nontreated control were included for comparison. The experimental units were arranged in a randomized complete block design with three replications. Water sensitive paper was used to quantify spray coverage and droplet characteristics. Crop injury was assessed at 14 days after planting (DAP), while weed biomass and grass, broadleaf, and sedge densities were evaluated at 21 DAP. UAS spray coverage ranged from 6% to 23% in 2024 and 4% to 19% in 2026, increasing significantly with carrier volume at estimated rates of 3 and 2 percentage points per additional GPA, respectively. Across years, weed biomass and grass density reductions increased significantly with UAS carrier volume, averaging 3 and 6 percentage points per additional GPA, respectively. Broadleaf and sedge density reductions also increased numerically by

approximately 2 percentage points per additional GPA, although neither linear trend was statistically significant. Comparing UAS applications at 2 and 8 GPA, mean weed biomass reduction increased from 44% to 62%, grass density reduction from 50% to 83%, broadleaf density reduction from 70% to 86%, and sedge density reduction from 77% to 87%, respectively. Spray coverage as low as 6% in 2024 and 4% in 2026 was associated with weed biomass, broadleaf, and sedge suppression that did not differ significantly from the conventional 15 GPA backpack application, which achieved 18% and 33% coverage, respectively. For grass suppression, the corresponding minimum coverage values were 6% and 8%, respectively. No visible edamame crop injury was observed with any herbicide application treatment in either year. These findings highlight the trade-off between reduced spray coverage at lower UAS carrier volumes and improved weed suppression at higher volumes, while demonstrating that relatively low spray coverage can still provide weed control not significantly different from conventional ground-based application.

188 - Height-Dependent Spray Deposition from a Multirotor Drone and Recovery of Quinclorac Activity with a Drift-Reduction Adjuvant

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Agricultural spray drones (ASDs) typically operate at heights above conventional ground sprayers, potentially increasing evaporative losses and reducing herbicide efficacy. Laboratory studies evaluated five discretely sized droplets representing the droplet spectrum of an ASD spray system, following a 5-m fall at 26°C and 49% relative humidity. Droplet diameter exhibited a sigmoidal loss, with 135-µm droplets losing 98% volume while droplets that ranged between 180 and 285 µm lost approximately 67% volume. Across the droplet spectral range reported for the XR11001 nozzle at the flow rate generated by the ASD, 88% of the intended spray would completely evaporate before reaching the target, assuming delivery at a 10-m height under these laboratory conditions. In another study, evidence for evaporative loss was also supported by a linear decline in droplets less than 150 µm based on analysis of stain objects on papers placed at 0.5-m increments over a vertical 10-m span. Regardless of the initial density of small droplets at 0.5 m from the sprayer, which varied depending on nozzle type and drift reduction agent (DRAs), the distance required to lose 50% of 150-µm diameter or smaller droplets was 6.6-m. Smooth crabgrass control decreased when an ASD applied quinclorac at 6 m compared to when applied at 2 m, but control was conserved by adding DRA or changing to an air-induction nozzle that generated coarse droplets. These data suggest that increasing ASD application height can reduce spray deposition and herbicide efficacy, but DRAs or air-induction nozzles can help offset these losses. ASD applications should be made at the lowest possible operational height and drift reduction technologies designed to reduce the number of small droplets should be employed where possible.

189 - Understanding How Drought and Auxin Herbicides Influence Goosegrass (*Eleusine indica*) Control

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[1]North Carolina State University

Poor goosegrass (*Eleusine indica*) control has recently been reported across the Mid-South and Midwestern US, with some cases involving dicamba applied with glyphosate. Extended periods of drought experienced in these regions raises questions about its contribution to reduced herbicide efficacy. A greenhouse experiment was conducted in 2025 at North Carolina State University to determine how soil moisture influences goosegrass response to postemergence herbicides. The experiment was arranged as a RCBD design with five replications and two runs. Treatments consisted of a 2 × 3 × 3 × 2 factorial, including glyphosate present or absent (Roundup PowerMAX3; 672 g ae ha^{-1}); three auxin levels: dicamba (Engenia; 560 g ae ha^{-1}), 2,4-D (Enlist; 1064 g ae ha^{-1}), or none; three graminicide levels: clethodim (Select Max; 76 g ai ha^{-1}), quizalofop-*P* (Assure II; 5 g ai ha^{-1}), or none; and two moisture regimes: well-watered (≥ 85% maximum water-holding capacity) and drought-stressed (25-30%). Glyphosate, clethodim, and quizalofop-*P* rates were selected from a prior dose-response experiment and corresponded to the LD_{75} for mortality. Dicamba and 2,4-D were applied at labeled 1x rates. All graminicide treatments included crop oil at 1% v/v. Applications were made to 10- to 11-cm goosegrass using a track sprayer calibrated to deliver 140 L ha^{-1}. Midday leaf (Ψ_leaf) and soil (Ψ_soil) water potential were measured using a dewpoint psychrometer and paired with a soil moisture retention curve to identify soil moisture conditions near turgor loss (25-30%) and field capacity (≥ 85%). Moisture regimes were imposed two weeks prior to application and maintained throughout the experiment gravimetrically. Averaged across graminicides, prolonged drought significantly reduced goosegrass control across glyphosate-containing treatments. Under well-watered conditions, glyphosate without an auxin provided 90% control, while glyphosate with dicamba reduced control to 77%. Conversely, glyphosate plus 2,4-D provided 93% control, comparable to glyphosate without an auxin. Biomass with glyphosate plus dicamba was 2.8- and 3.6-fold greater than with glyphosate without an auxin and glyphosate plus 2,4-D, respectively. Under extended drought conditions, glyphosate without an auxin and glyphosate plus dicamba provided only 27-29% control, whereas glyphosate plus 2,4-D improved control to 48%. Under the conditions evaluated in this experiment, dicamba showed potential to reduce glyphosate's control of well-watered goosegrass, whereas 2,4-D did not. However, prolonged drought substantially reduced goosegrass control regardless of the auxin herbicide combined with glyphosate.

190 - Integrating Cover Crop Termination Timing and Herbicide Programs for Weed Control in New York Corn

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[1]Cornell University

Field experiments were conducted in growers' fields in Waterloo, NY, in 2024 and 2025 to evaluate early (ET) and late (LT) cover crop termination, in combination with seven herbicide programs. LT occurred after corn (*Zea mays* L.) planting in 2024 but before planting in 2025 because of delayed planting. Cover crops included crimson clover (*Trifolium incarnatum* L.), Austrian winter pea (*Pisum sativum* L.), and volunteer wheat (*Triticum aestivum* L.) in 2024, and Austrian winter pea, crimson clover, radish (*Raphanus sativus* L.), turnip (*Brassica rapa* L.), sunflower (*Helianthus annuus* L.), and volunteer wheat in 2025. Herbicide programs included glyphosate alone, glyphosate combined with *s*-metolachlor, *s*-metolachlor + atrazine or *s*-metolachlor + mesotrione, with or without subsequent postemergence (POST) dicamba. In 2024, when waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer), common lambsquarters (*Chenopodium album* L.), and foxtail (*Setaria* spp.) were dominant, LT increased cover crop biomass from 4,241 to 10,316 kg ha^{-1} and reduced total weed density by 77% before POST dicamba application and 45% later in the season compared with ET. Under glyphosate alone, total weed biomass was 32-fold greater under ET compared to LT. In 2025, LT increased cover crop biomass by only 20%, from 2,421 to 2,907 kg ha^{-1}, and the weed community was dominated by velvetleaf (*Abutilon theophrasti* Medik.). *S*-metolachlor + mesotrione followed by (*fb*) dicamba and *s*-metolachlor + atrazine *fb* dicamba reduced velvetleaf biomass by 93% and 85%, respectively, compared with glyphosate alone at 8 weeks after replanting. *S*-metolachlor + mesotrione *fb* dicamba resulted in the highest corn yield among treatments in both years, with 12,645 kg ha^{-1} in 2024 and 7,480 kg ha^{-1} in 2025. Relative contribution analysis associated 47% and 60% of weed biomass variation to herbicide program in 2024 and 2025, respectively, compared with 26% and 6% to termination timing. Corresponding contributions to corn yield variation were 48% and 87% for herbicide program and 13% and 2% for termination timing. Herbicide program accounted for more variation in weed biomass and corn yield in both years.

191 - Rootzone pH Influences the Population Dynamics of Creeping Bentgrass (*Agrostis stolonifera*) in Annual Bluegrass (*Poa annua*) Putting Green.

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Creeping bentgrass (*Agrostis stolonifera* L.; CBG) putting green is disrupted by annual bluegrass (*Poa annua* L.; ABG) weed encroachment. Synthetic herbicides provide rapid weed suppression; however, they may create voids, provide less long-term control, or cause turf injury. Several greenhouse studies suggested that ABG aboveground growth increased in high soil pH (~6.5) compared to acidic pH conditions. There is a need to identify cultural non-chemical weed control options that increase CBG encroachment into ABG putting green. A field experiment was conducted beginning in 2025 on a >10-year-old ABG putting green at Rutgers Hort Farm No. 2 on plots with an established pH gradient created with lime application. The objective was to evaluate the effect of rootzone pH on CBG encroachment into ABG putting green. The experiment was a split plot design with 10 treatments. Five treatments consisted of lime applied annually at increasing rates. Four treatments that did not receive lime included monthly amendments of phosphorus (20 kg P_2O_5 ha^{-1}), and nitrogen (5 kg N ha^{-1}), gypsum (calcium), and gypsum + nitrogen. Mat layer was sampled twice annually, in May and November, to assess rootzone pH and

nutrients. In May 2026, mat layer sampling had rootzone pH ranging from 4.9 to 5.5 in non-lime treatments to 7.0 for the highest lime rate. Rootzone Ca ranged from 500 to 5427 mg/kg in the high-lime-treated plots and 400 to 580 mg/kg in gypsum treatments, while <354 mg/kg in non-lime-treated plots. Bentgrass cultivars ‘Oakley’ and ‘Penncross’, four plugs each, were harvested from a putting green nursery, and top 1 cm planted into the ABG in June 2025. Bentgrass cover was measured at intervals using a grid intersect count, with each plug measuring 20 intersects at planting. Turf quality of ABG was measured monthly. Treatment by cultivar interaction was significant for bentgrass encroachment in May and August 2026. Fourteen months after planting, Oakley cover measured to 60 intersects in non-lime treated (5.0 pH) and less (43) in neutral pH (7.0). Penncross measured to <25 intersects and was largely not affected by lime or other amendments. Gypsum + nitrogen amendment or nitrogen alone under acidic conditions resulted in Oakley cover of <38 intersects which was similar to neutral pH treatments. This suggests rootzone calcium is largely responsible for ABG competitiveness in CBG. The turf quality of ABG in neutral pH or gypsum + nitrogen (>7.7) compared to nitrogen and non-lime treatments (<6) explained increased bentgrass encroachment into ABG putting green. This information provides alternative approaches for golf course superintendents desiring safe and gradual long-term ABG control while increasing CBG encroachment into ABG putting green.

192 - Electrical Weed Control and Cultivation Effects on Weed Communities and Soil Health in Organic Apple Orchards

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In NY and across the greater US, weeds are a major barrier to organic production. Weed management in organic perennial fruit systems relies heavily on cultivation, which can degrade soil health. Electrical weed control (EWC) is an emerging non-chemical alternative, but information on its efficacy in orchards is limited. In 2025, field experiments were conducted in two mature organic apple orchards in Ithaca, NY to compare the effects of EWC and cultivation on weed cover, community composition, biomass, and soil health. Treatments consisted of three-monthly applications of EWC, cultivation, EWC followed by cultivation (EWC fb cultivation), or a non-treated control (NTC). These were arranged as a randomized complete block design with four replications per site. EWC-based treatments significantly reduced total weed cover relative to cultivation and the NTC ($P < 0.0001$); however, no significant differences were detected between EWC and EWC fb cultivation by the end of the growing season. In addition, EWC-based treatments maintained weed cover at ≤13% from 23 July 2025 to 21 April 2026. End-of-season weed community composition and its characteristics diverged among the EWC-based treatments, cultivation, and NTC. Compared with cultivation, EWC-based treatments reduced end-of-season weed biomass by 65-66%. In addition, EWC fb cultivation was associated with lower wet aggregate stability, active carbon, and soil respiration than the NTC. These results indicate that following EWC with cultivation provided no additional weed suppression. Further, it was associated with lower values for several soil health indicators; however, this study represents a single growing season within one production region. Additional multi-year and transregional studies are necessary to determine the

consistency of these responses and assess EWC's long-term impact on weed communities and soil health in perennial production systems.

193 - Planting Green Effects on Environmental Fate of Atrazine

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Planting green can amplify cover crop benefits by increasing the amount of surface residue. Increased surface residues and delayed cover crop termination timing may also affect water runoff patterns and herbicide fate. Many no-till growers who are interested in adopting planting green practices employ soil-applied residual herbicides for weed control. We conducted a three-year field study to determine how cover crop termination timing affects soil-applied herbicide environmental fate. We terminated a cereal rye (*Secale cereale* L.) cover crop either two weeks before planting (early kill treatment) or one day after corn (*Zea mays*) planting (planting green treatment). Atrazine (1.12 kg ai ha^{-1}) was applied both at corn planting and three weeks after planting. We hypothesized that planting green would increase cover crop residue biomass, increase cover crop interception of atrazine, and reduce water runoff volume which would reduce runoff atrazine concentrations. Field scale lysimeters that collected surface and subsurface runoff from each plot (15 by 27 m) were used to measure surface and subsurface water runoff volumes and concentrations of atrazine. Cover crop residue biomass was up to 4x higher in the planting green treatment compared to planting green at corn planting. In two of the three years, atrazine concentration in the residue was 50% higher in the planting green treatment than early kill treatment, and early season atrazine concentration in the soil was significantly lower in the planting green treatment. Planting green changes both cover crop biomass and fate of soil-applied herbicides in these systems.

194 - Evaluating Genetic Shifts of Palmer Amaranth (*Amaranthus palmeri*) Populations Across North Carolina Between 2010 and 2022

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Palmer amaranth (*Amaranthus palmeri*) has been a consistently problematic weed across North Carolina, with herbicide resistance confirmed to seven different modes of action within the state. Although resistance has been thoroughly documented, the mechanisms underlying its dispersal among populations remain insufficiently understood. To better understand the distribution of genetic variation, statewide surveys were conducted in 2010, 2015, and 2022, during which populations were screened for resistance. Further genetic characterization was needed to evaluate genetic diversity and relationships among these populations. A total of 300 plants were selected from the previous statewide surveys, with 100 plants representing unique populations from each survey year. Additionally, nine populations were selected for more intensive genetic characterization, with 20 plants sampled from each population. These populations represented three geographic regions of North Carolina (Coastal Plain, Piedmont, and Tidewater), with

one population from each survey year represented within each region. This resulted in an additional 180 plants, bringing the total number of plants evaluated to 480. Whole-genome sequencing was performed on individual plants, and initial genome-wide genetic variation was evaluated using a k-mer-based approach that approximates genetic distance without reference genome alignment. Genetic relationships among sampled plants were subsequently assessed using principal coordinate analysis (PCoA). Preliminary results show that genetic diversity within populations can be comparable to that observed among populations, suggesting that there is not strong population structure across North Carolina. Geographic distance did not consistently correspond with genetic differentiation among sampled populations, although a few populations appeared to represent unique genetic signatures. Further analyses will focus on the development and distribution of herbicide resistance in Palmer amaranth populations across North Carolina.

195 - Clomazone and S-metolachlor Efficacy and Crop Safety in Fall Planted Carinata (*Brassica carinata*)

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The production and development of new biofuel crops have increased in the southeastern United States, with oilseed crops such as *Brassica carinata* A. Braun (carinata) of particular interest because of its potential to fit into growers existing crop rotations. However, it is essential to determine the safety of carinata to herbicide programs commonly used in that region. The objective of this study was to evaluate the performance of carinata with preemergence application rates of *S*-metolachlor (935 or 1870 g a.i. ha^{-1}), clomazone (91 or 182 g a.i. ha^{-1}), and a postemergence application of clopyralid (105 or 210 g a.i. ha^{-1}) four weeks after planting. The study took place in the Fall-Spring season of 2023-2024 at two locations in Goldsboro, North Carolina (northern and southern Goldsboro) with three visual injury and weed control ratings occurring at 6,8 and 12 weeks after treatment. Data was analyzed as a repeated measures split plot ANOVA separately by location with POST applications as the main plot, and PRE applications as the split plot. Low *S*-metolachlor crop injury was observed for both rates and locations (3% - 11%). Moderate clomazone injury was observed at the southern location with the low dose (12 to 23%), with injury peaking with the high dose 8 WAT at 58%. Some recovery was observed by 12 WAT with only 43% injury from the high clomazone rate. Clomazone provided excellent weed control (> 97.5%) of all weeds at both locations and with both doses. The high dose of *S*-metolachlor provided equivalent control to clomazone at all timings and locations except with *Lamium amplexicaule* at 6-WAT and *Spergula arvensis* at 12-WAT. Overall, greater weed control and carinata yield was observed in treatments with clomazone, although greater carinata injury was observed with its high rate. To find the best balance of crop injury and weed control with clomazone, a dose-response study was conducted in the 2024 - 2025 season in Clinton and Kinston, NC with 10 rates between 2.8 g a.i. ha^{-1} and 182 g a.i. ha^{-1} plus a non-treated control. Both visual injury and weed control peaked 12 WAT with an average of 26% and 35% injury in Kinston and Clinton respectively at 91 g a.i. ha^{-1}, 100% control of *L. amplexicaule* and 30% to 90% control of *P. annua*. Yields remained the same across all herbicide treatments. In conclusion, the

greater carinata injury observed with clomazone did not reduce yields compared to the visually safer *S*-metolachlor while providing excellent weed control. Based on our findings, we recommend PRE applications of clomazone at 91 g a.i. ha^{-1} as the best balance of crop safety and weed control in carinata.

196 - Do cultural practices affect oat-ragweed competition in reduced-tillage organic systems?

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[1]Penn State University

Small grain varieties available for organic growers are often bred using conventional management practices. Small grain breeding programs prioritize traits such as yield stability, reduced lodging, and reduced disease severity. Small grain varieties developed with the use of herbicides to terminate weeds may not have traits that lead to crop interference. Common ragweed (*Ambrosia artemisiifolia*) is an early-emerging summer annual weed that is prevalent in reduced tillage organic rotations. Weed seed rain in reduced tillage soybean can result in greater weed-crop competition in subsequent phases of the cropping rotation. We conducted a field experiment near Rock Springs PA in 2026 to evaluate how cultural practices mediate interactions between three hulless oat varieties (Gehl, Nitro, Streaker) and ragweed over time. Piecewise structural equation modeling (pSEM) was used to model interference or tolerance of ragweed among hulless oat varieties. Results indicate that early oat vigor is required to reduce ragweed vigor at harvest, which was mediated by oat vigor at heading. The interaction between hulless oat varieties and ragweed varied, with interference observed in only one variety (Nitro). Within four weeks after planting the hulless oat variety, Nitro has the greatest emergence and height, resulting in reduced early ragweed vigor. In the future, research will investigate the use of multispectral imagery as a high throughput, non-destructive method to evaluate crop interference of small grain varieties.

197 - Trust Your Spray? A Blacklight Self-Test

Newman Teye-Doku[1], Ramawatar Yadav[1]

[1]The Ohio State University

How well a researcher sprays herbicide treatments affects small-plot research data quality and the applicator’s safety. Graduate students often begin spraying research plots after brief, informal training, and although calibration is widely taught, few researchers ever see where their spray lands. Drifting into an untreated check can be easy to detect through visible assessments, but spray that lands in a neighboring treated plot is masked by expected symptoms and can go undetected. Fluorescent tracers are typically used in spray technology research and safety training but rarely used for self-assessment in small-plot research purposes. The objective of this extension video was to demonstrate a simple, low-cost self-test of spray application technique. A mock trial consisted of 3 by 6 m plots with three treatments, two fluorescent pigments (orange and green) and an untreated check, was arranged in three replications. Treatments were applied with a CO2-pressurized backpack sprayer fitted with AIXR11002 nozzles using the operator's usual spray technique. Witness cards and weeds in plots, plus the operator's PPEs, were

examined under 365 nm ultraviolet light. Spray deposition was heaviest at plot edges, where the spray line was purged before entering the plot and adjacent passes overlapped, indicating plot borders received a higher dose than plot centers. No tracer was detected on untreated check cards placed in the plot center. Purging outside the plot boundary and adjusting boom height were identified as corrective steps to keep spray deposition within the plot centers. The video encourages graduate students and experienced researchers to run this self-test, identify habits that compromise data quality and safety, and correct them before their next trial.

NEWSS Student Contest Papers – M.S.

198 - Don't Get Stumped: Strategies for Managing Tree of Heaven (*Ailanthus altissima*).

Miriam Styer[1], Ramawatar Yadav[1]

[1]The Ohio State University

Tree of heaven (*Ailanthus altissima* (Mill.) Swingle) is an invasive tree species that rapidly spreads and outcompetes native plants. It is also the preferred host of the new invasive insect spotted lanternfly (*Lycorma delicatula*). Spotted lanternfly is becoming a serious pest in grapes and can also be a problem in tree fruits and hops. Managing tree of heaven can be challenging for several reasons. It can be easily confused with two native lookalikes: black walnut (*Juglans nigra* L.) and sumac (*Rhus* spp.). Once tree of heaven has been identified, removal is difficult due to its ability to send up root sprouts after being cut down. Although herbicides can improve tree of heaven control, there is a not a one-size-fits-all approach to herbicide application. Herbicide selection and method of application vary based on the size of the tree. The aim of this video is to improve audience understanding of how to identify tree of heaven and use an herbicide treatment to effectively manage this species. The video showcases how to identify tree of heaven and differentiate it from black walnut and sumac. A brief explanation of the different herbicide application methods with a demonstration of each method is provided. Improving awareness of how to correctly identify and control tree of heaven can help reduce the spread of this invasive species.

199 - “Getting Glufosinate Right” for Better Weed Control

Sithin Mathew[1], Debalin Sarangi[1]

[1]University of Minnesota

Glufosinate is a commonly used herbicide in soybean production to manage glyphosate and auxin-resistant weeds such as waterhemp. However, as a contact herbicide, its efficacy depends on proper application methods and spray coverage. This video explain the effects of glufosinate formulation (next-generation vs. generic), carrier volume, adjuvants, and nozzle type on glufosinate efficacy. Three separate randomized complete block experiments with four replications were conducted at the Rosemount

Research and Outreach Centre, Rosemount, MN, in 2026. Experiment 1 evaluated three carrier volumes (10, 15, and 20 GPA), experiment 2 evaluated three ammonium sulfate (AMS) rates (0, 1.5, and 3 lb A^{-1}), and experiment 3 compared two nozzle types (XR and AIXR) on weed control and soybean yield. The results showed that the generic glufosinate formulations, Surmise® 5 and Interline®, provided greater than 95% control of waterhemp and velvetleaf at the highest carrier volume (20 GPA). However, increasing carrier volume did not improve common lambsquarters control. In contrast, the next-generation formulation Liberty Ultra® provided consistent control of all three weed species across carrier volumes. Compared with no AMS, adding AMS at 3 lb A^{-1} improved velvetleaf control from 73 to 93% with Surmise® 5 and from 88 to 96% with Interline®. Waterhemp control also improved from 93 to 96% when AMS increased from 1.5 to 3 lb A^{-1} with Surmise® 5. At the lower Liberty Ultra® rate (6 fl oz A^{-1}), the XR nozzle provided greater control of velvetleaf and common lambsquarters than the AIXR nozzle (50 vs. 30% and 48 vs. 22%, respectively). Nozzle type did not influence waterhemp control at any herbicide rate, and differences between nozzle types were not observed at higher Liberty Ultra® rates (24 fl oz A^{-1} or higher). Overall, generic glufosinate formulations can provide effective weed control when applied with higher carrier volumes and AMS rates. Therefore, optimizing herbicide application with appropriate carrier volume or adjuvants can improve glufosinate performance.

200 - Why Does Glufosinate Application Timing Matter?

Sumya Binta Belayet[1], Sarah Ganske[1], Matheus Luiz De Paula[1], Isaac Goncalves[1]

[1]Kansas State University

Applying glufosinate at the right time requires attention to both weed size and crop growth stage. Weeds must be treated within the size limits specified on the product label, and the crop must remain within the labeled application window. Delaying treatment can allow weeds to become more difficult to control or the crop to advance beyond the permitted application stage. This educational video uses soybean to explain how crop development influences glufosinate application decisions. It emphasizes recognizing the beginning of flowering, checking the crop-stage cutoff on the specific product label, and distinguishing crop-stage restrictions from preharvest intervals. Meeting a preharvest interval does not permit an application beyond the labeled crop-stage cutoff. Because glufosinate provides little or no residual weed control, scouting after application helps identify surviving weeds and newly emerging weeds. Before considering a sequential application, growers must confirm that the crop remains within the labeled window and check the minimum retreatment interval, preharvest interval, maximum number of applications, and annual use limits. Weed size, weather conditions, and spray coverage must also be considered. The video provides students, applicators, and growers with practical guidance for planning timely applications and following the directions for the specific glufosinate product being used.

201 - Does Glufosinate Formulation Impact Grass Control?

Mariana de Oliveira Mota[1], Sarah Ganske[1], Michael W. Marshall[2], Isaac Goncalves[1], Isadora Saldanha Balbinot[1], Mateo Kokic[1], Matheus Luiz de Paula[1], Milena Nero[1]

[1]Kansas State University, [2]Clemson University

Glufosinate is a non-selective, contact herbicide widely used for postemergence grass control, and reformulated products are often introduced with claims of improved efficacy. The first objective of this study was to compare control of yellow foxtail [*Setaria pumila* (Poir.) Roem. & Schult.] and large crabgrass [*Digitaria sanguinalis* (L.) Scop.] by two glufosinate formulations. The second objective was to evaluate the influence of grass height at the time of application on herbicide efficacy. A field experiment was conducted at Ashland Bottoms Research Farm, near Manhattan, KS, in a randomized complete block design with four replications. Treatments consisted of glufosinate-P-ammonium (0.32 kg ha^{-1}, formulated as Liberty Ultra) and glufosinate-ammonium (0.65 kg ha^{-1}, formulated as Interline) applied at three timings based on weed height: 5 to 10 cm (POST1), 13 to 18 cm (POST2), or 20 to 30 cm (POST3), plus an untreated control, for a total of seven treatments. All herbicide treatments included ammonium sulfate at 3.4 kg ha^{-1}. Weed control (0 to 100%) was estimated visually at 7, 14, and 28 days after application (DAA), and dry biomass was harvested at 28 DAA. Because model diagnostics indicated non-normal residuals, data were analyzed using generalized linear mixed models for visible control (analyzed separately by species and rating date) and gamma for dry biomass. In both models, formulation, application timing, and their interaction were fixed effects, and replication was a random effect. Means were compared using analysis of variance with Sidak’s post hoc comparisons (α= 0.05). Responses were similar for both grass species for all application and evaluation timings. No differences between formulations were detected in visible control at 7 DAA. For POST2, glufosinate-ammonium provided greater control than glufosinate-P-ammonium at 14 and 28 DAA (60% vs. 26% and 24% vs. 11%, respectively). Glufosinate-ammonium also outperformed glufosinate-P-ammonium at 28 DAA POST3, although control was low for both formulations (34% vs. 25%). For dry biomass, only glufosinate-ammonium differed from the nontreated control, with reductions of 52% at POST1 and 56% at POST3. Biomass reductions with glufosinate-P-ammonium (30 to 41%) were similar at all application timings. Glufosinate-ammonium at POST1 presented the lowest weed dry biomass, outperforming all the other treatments. These results suggest that grass control by glufosinate-ammonium and glufosinate-P-ammonium was similar under experimental conditions. Weed size and regrowth potential should be considered together with product choice when planning postemergence programs.

202 - Herbicide Metabolism Matters: Understanding Insecticide-Herbicide Interactions

Adebisi Adeleke[1], Debalin Sarangi[1]

[1]University of Minnesota

The ability of plants to metabolize herbicides plays an important role in crop tolerance to certain herbicides and may also contribute to herbicide resistance in weeds. Interactions between insecticides and herbicides can affect this process, potentially altering plant responses to herbicide applications. Cytochrome P450 enzymes help plants break down certain herbicides into less active compounds, allowing crops to tolerate these herbicides. Malathion is an insecticide that can interfere with this process by inhibiting these enzymes. This educational video uses malathion to demonstrate how herbicide metabolism helps corn (*Zea mays*) tolerate mesotrione and explores its potential role in 2,4-D resistance in waterhemp (*Amaranthus tuberculatus*). A greenhouse demonstration compared four corn treatments: a nontreated control, malathion alone at 2,000 g ai ha^{-1}, mesotrione alone at 105 g ai ha^{-1}, and malathion

applied before mesotrione at the same respective rates. Corn treated with mesotrione alone showed no visible injury, demonstrating its tolerance to the herbicide. In contrast, corn treated with malathion before mesotrione developed severe bleaching, characterized by white and pale-yellow leaves. This response illustrates how malathion can interfere with cytochrome P450 enzymes involved in herbicide metabolism, increasing corn sensitivity to mesotrione. To explore the potential role of herbicide metabolism in resistance, a similar approach was used in a 2,4-D-resistant waterhemp population. Plants were treated with malathion alone, 2,4-D alone at 1,063 g ae ha^{-1}, or malathion followed by 2,4-D, and survival was assessed 21 d after treatment. Unlike the response observed in corn, malathion pretreatment did not significantly increase waterhemp sensitivity to 2,4-D. This suggests that inhibiting cytochrome P450 enzymes with malathion was not enough to overcome 2,4-D resistance in this population. Overall, these observations highlight the importance of herbicide metabolism in crop tolerance and the complexity of its potential role in herbicide resistance. The contrasting responses in corn and waterhemp demonstrate that pesticide interactions can affect plants differently. Understanding these interactions can help growers and pesticide applicators recognize factors that may affect herbicide performance and crop safety.

NCWSS Student Video Contest

203 - Innovative Technologies for Weed Management: Exploring Directed Energy for Flora Control

Isadora Saldanha Balbinot[1], Sarah Ganske[1]

[1]Kansas State University

Herbicide resistance is one of the major challenges for weed control. The increasing number of herbicide-resistant weed populations, combined with the limited introduction of herbicides with new modes of action, highlights the need to develop alternative weed control strategies. Directed energy is an emerging nonchemical technology being developed by Global Neighbor, Inc., that combines two wavelengths of electromagnetic radiation to control weeds. The first is mid-wave infrared (MWIR) radiation, operating at approximately 3 µm, which delivers thermal energy to plant tissue without producing an open flame. The second is indigo light, operating at approximately 440 nm within the visible spectrum, which may contribute to plant injury when delivered at high intensities. Directed energy combines these two wavelengths and aims to damage plant tissue and provide an alternative approach to weed control. This study is being developed to evaluate the effectiveness of directed energy for controlling Palmer amaranth (*Amaranthus palmeri*) in cotton systems. The study presents two experiments using a randomized complete block design with four repetitions. The first experiment consists of seven treatments, including five exposure times (3, 6, 9, 12 and 15 seconds), a standard herbicide and an untreated control. The second experiment aims to determine whether sequential applications improve weed control compared with a single exposure, this experiment consists of five treatments including two selected exposure times applied once, the same exposure times applied twice and an untreated control. This research aims to provide new information on the potential of directed energy as a nonchemical weed management strategy and to identify exposure durations and application strategies that may improve weed control.

204 - From Field to Lab: Understanding the Process to Confirm Herbicide Resistance.

Jessie R. Lewis[1], Bryan G. Young[1]

[1]Purdue University

Multiple testing measures are used for herbicide resistance confirmation, but vary in time requirements, labor efficiency, accuracy, and cost. Greenhouse whole-plant assays are a common and reliable measure used to confirm and determine the resistance level through dose response or discriminating single dose experiments. Drawbacks of whole-plant assays include: large amounts of seed required to be collected from putative resistant female plants in the field, greenhouse space requirements, and several months of plant propagation and experimental throughput. This makes it difficult to recommend immediate control tactics in time for the following growing season. Quick herbicide-resistance assays have been developed and adopted for resistance testing; however, no single assay is suitable for all herbicide sites of action, resistance mechanisms, or weed species. Molecular DNA assays using genetic markers, which are primarily based on polymerase chain reaction (PCR) or quantitative PCR, can provide a qualitative result within 24 hours of analysis. However, these tests are largely limited to detecting known target site mutations that were previously confirmed to exist. Therefore, the presence or absence of the specific polymorphism the marker was designed to detect does not mean there is no involvement of an additional resistance mechanism, such as nontarget site resistance. Physiological forms of rapid assays include whole plants, seed germination, root, and leaf discs. The United Soybean Board saw value in supporting collaborative research through the Herbicide Resistance and Monitoring Network. This project brings together researchers from land-grant universities across the country to identify new and emerging cases of herbicide resistance and better understand the mechanisms behind them. The overarching goal of the project is to use that information to develop rapid physiological and molecular assays that can detect resistance faster and at a lower cost allowing for in-season management decisions.

205 - Make Every Drop Count: Understanding Adjuvant Performance

Abigail N. Norsworthy[1], Bryan G. Young[1]

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While herbicide selection receives considerable attention, adjuvant selection can be equally critical to the performance of foliar applications. Adjuvants have the potential to improve biological efficacy by increasing spray droplet retention, leaf surface coverage, and herbicide penetration. Despite these benefits, improper adjuvant selection or assessment of environmental conditions can be costly, with reduced herbicide efficacy or increased crop damage as a possible outcome. Therefore, this video highlights two commonly used adjuvant categories, nonionic surfactants (NIS) and oil-based penetrant adjuvants, and offers practical strategies for selecting adjuvants based on environmental conditions. Nonionic surfactants reduce the surface tension of the spray solution, improving spray coverage and contact area, especially on leaf targets with leaf hairs or other irregular leaf surface features. Oil-based

adjuvants, such as crop oil concentrates (COC) and modified seed oils (MSO), enhance herbicide penetration through the leaf cuticle. This video promotes best practices for adjuvant selection based on herbicide type and environmental conditions, while emphasizing proper product label adherence to optimize herbicide efficacy for crop safety and foliar weed control.

206 - Strip Tillage and Weed Management: Making the System Work For You

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[1]Michigan State University

Weed control and managing herbicide resistance remains a primary concern for farmers, especially when it comes to conservation practices. Farmers are already struggling to control weeds with current tillage and herbicide practices, and they are hesitant to add any complexities that could compromise their existing weed control, harm their crop yields, or decrease their profitability. However, further integrating their weed management programs with other approaches can help reduce weed populations and the spread of herbicide-resistant weeds. Strip-tillage is an approach that combines the reduced soil disturbance of no-till and the ideal crop planting conditions of tillage into one growing system. The introduction of cover crops and no-till practices have been a major research priority in weed science and has shown that weeds can still be controlled; however, growers' uncertainty comes from a lack of practical guidance for combining and implementing these practices on their own farms. The objective of this video is to outline important factors for considering strip-tillage adoption to control weeds and protect yields. This video will help growers determine whether these practices are suitable for their own operations. It will then cover logistical factors such as existing rotations and timing, how to incorporate strip tillage, selection of cover crops, and updating herbicide programs to coincide with cover crop management, all while making sure weed control remains a top priority. Weeds will be present under any management system, and planning these decisions with weeds in mind will help make the system successful.

207 - A Guide to Common Grass Weed Identification

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Despite many grass weed species appearing visually similar, especially during early vegetative stages, correctly identifying and differentiating between them is a crucial step for informing effective weed management. Early identification of weed seedlings is essential for effective control and crop yield protection, as identification at reproductive maturity may be too late to prevent seed set and subsequent population establishment. Common grass weeds differ in their growth and reproductive characteristics, which influence their emergence, establishment, and spread in agricultural fields. To facilitate grass weed seedling identification, this short video describes foundational anatomical structures around the collar region, including the stem, leaf blade, leaf sheath, collar, ligule, and auricle. Applying these anatomical features, the video demonstrates identification of three common grass weeds in Minnesota: quackgrass

[*Elymus repens* (L.) Gould], barnyardgrass [*Echinochloa crus-galli* (L.) P. Beauv.], and green foxtail [*Setaria viridis* (L.) P. Beauv.]. A dichotomous key with instructions for identifying twelve of the most common grass weeds in Minnesota is also provided, allowing for a more comprehensive field guide that can be referenced as needed. This video aims to increase knowledge of grass anatomy and grass weed identification, improve grass weed monitoring and management, and reduce their spread.

208 - Understanding Vyconic Soybean Technology and Its Role in Weed Management

Milena Nero[1], Isaac Goncalves[1], Matheus Luiz de Paula[1], Mateo Andres Kokic[1], Eduardo Rodrigues de Moraes[1], Igor Rezende Lima[1], Mariana de oliveira Mota[1], Isadora Saldanha Balbinot[1], Sumya Binta Belayet[1], Sarah Ganske[1], Yasir Parrey[1]

[1]kansas State University

Herbicide-resistant weeds continue to complicate weed management in soybean production, underscoring the importance of diversified strategies that reduce reliance on individual herbicide sites of action. Vyconic™ soybeans are tolerant to five herbicides: glyphosate, glufosinate, dicamba, 2,4-D, and mesotrione, pending regulatory approvals. The objectives of this educational video are to explain how Vyconic™ soybean technology could expand herbicide options for weed management, pending regulatory approvals, and to highlight the importance of selecting and integrating these options within responsible weed management programs. The availability of different herbicide options may support the development of weed management programs better adapted to the needs of each field. Mesotrione, a Group 27 herbicide that inhibits the HPPD enzyme, could offer soybean growers an additional herbicide option with both foliar and residual activity, pending regulatory approvals. Combining mesotrione with other herbicide options could provide growers with an additional site of action to help control emerged weeds and manage subsequent weed emergence. However, expanding herbicide options does not, by itself, guarantee more effective herbicide resistance management. Herbicide selection should consider the weed species present, field management history, the herbicide sites of action used, and integration with other control practices. These strategies are important for reducing selection pressure and preserving herbicide effectiveness over time. Therefore, understanding the characteristics of Vyconic™ soybean technology and its potential applications is essential for evaluating its role in developing diversified and responsible weed management programs in soybean production.

209 - Waterhemp Survivors: Resistance or Something Else?

Mateo Andres Kokic[1], Sarah Ganske[1], Igor Rezende Lima[1], Milena Nero[1], Sumya Binta Belayet[1], Yasir Parrey[1], Isadora Saldanha Balbinot[1], Matheus Luiz de Paula[1], Liam Vincent[2], Ingo Meiners[2], Aimone Porri[2]

[1]Kansas State University, [2]BASF Corporation

Anyone who has managed waterhemp (*Amaranthus tuberculatus*(Moq.) Sauer) in soybeans knows the feeling: you spray, you walk the field a couple of weeks later, and some plants are still standing. It’s easy

to assume the worst. But surviving a herbicide application doesn’t automatically mean a weed is resistant, and figuring out why the weed was not controlled is the right place to start before deciding what to do next. In 2022, a waterhemp population in eastern Kansas escaped control after several herbicide applications, including glufosinate. Ten additional fields from the area were sampled during 2025 and treated with 0.45 kg ai ha^{-1} of glufosinate-P-ammonium in a greenhouse. More than 20% of the sprayed plants survived in two populations; 10% to 19% survived in two populations; and 5 to 9% survived in three populations. In the remaining three populations, survival ranged from 0 to 5%. This video will explain what these results mean for soybean growers, discuss the common reasons herbicide applications fail to control weeds, describe what to look for when you find weeds that survive a herbicide application, and explain when and why to call an Extension specialist or other expert to conduct further testing to confirm whether resistance is present. The most important message from this video is that not every surviving weed is resistant, but every survivor is worth a second look. Documenting potential resistance early and asking for help when you need it leads to better decisions and better waterhemp control.

210 - Postemergence Glufosinate Tank Mixtures: Should Soybean Injury Be a Concern?

Matheus Luiz de Paula[1], Sarah Ganske[1], Bryan G. Young[2], Anthony Louis Perretta[2], Isaac Gonçalves[1], Mateo Kokic[1], Isadora Saldanha Balbinot[1], Igor Rezende Lima[1], Mariana de Oliveira Mota[1]

[1]Kansas State University, [2]Purdue University

Seeing soybean (*Glycine max* (L.) Merr.) injury after an herbicide application can be unsettling for farmers. Visible injury may raise concerns about yield loss and crop management. This video will answer a practical question: does visible soybean injury following postemergence herbicide applications indicate grain yield loss? It will describe initial crop injury, subsequent recovery, and final grain yield. The educational objective is to help farmers understand that visible soybean injury following herbicide applications is not necessarily associated with grain yield loss. A field experiment conducted in 2026 at Ashland Bottoms Research Farm near Manhattan, Kansas, evaluated soybean injury and recovery following eight herbicide treatments applied at V5-V6 or R2. The soybeans were glufosinate resistant. All mixtures contained glufosinate-P-ammonium and ammonium sulfate. Plots were maintained weed-free throughout the trial. Visual herbicide injury was evaluated at 3, 7, 14, 21, and 28 days after treatment (DAT). Across mixtures, mean injury following V5-V6 applications declined from 16% at 3 DAT to 14% at 7 DAT and 7% at 14 DAT. Corresponding means following R2 applications were 11%, 8%, and 4%. Visual herbicide injury was absent at 28 DAT at both application timings. At harvest, soybean yield was similar among the eight mixtures at each application time but differed between application times. Soybeans treated at V5-V6 averaged 62.3 bu $acre^{-1}$, compared with 56.4 bu $acre^{-1}$ for those treated at R2. Although V5-V6 applications caused greater early injury, they also had higher average yields, illustrating that visible crop injury alone does not indicate how much yield may be lost.

211 - Spray Deposition as Influenced by Application Method Across Soybean Growth Stages

Breno Rodrigues[1], Milos Zaric[1], Ana Laura Camachos de Oliveira[1], Gustavo Fujihara[1], Jeffrey Golus[1], Kasey Schroeder[1], Rasmita Mainali[1], Shrijana Poudel[1], Renata Naves[1], Vojin Milosevic[1]

[1]University of Nebraska-Lincoln

Effective pest management relies on adequate deposition of crop protection products within targeted areas of the crop canopy, where pests are present. In soybean (*Glycine max* (L.) Merr.) changes in canopy architecture throughout the growing season can influence spray penetration and distribution, potentially limiting deposition on targeted plant surfaces and affecting pest management efficacy. Therefore, this study aimed to evaluate application methods across five soybean growth stages (V1/V2, V6/V7, R2, R5, and R7) to assess spray deposition efficiency. Single-fan (MR11003) and dual-fan (MR110015) nozzle configurations were evaluated to assess the effects of spray orientation on deposition. Single-fan nozzles were positioned forward, backward, or in alternating orientations using adapters, whereas dual-fan configurations were evaluated with both fans directed vertically downward or arranged symmetrically. Four collectors, each equipped with five water-sensitive cards oriented top, forward, backward, left, and right relative to the direction of travel, were placed within each plot to quantify spray coverage and droplet density at each soybean growth stage. Applications were made with a backpack sprayer configured to deliver 187 L ha^{-1} water with 50.8 cm nozzle spacing and boom height at 276 kPa. Data from all water-sensitive card orientations were pooled to evaluate spray deposition across soybean growth stages and nozzle configurations. At the V1/V2 growth stage, the dual fan nozzles produces the most droplets delivered to the water sensitive cards and would be adequate when applying systemic herbicides requiring more droplets. The single-fan MR11003 nozzle oriented vertically downward provided the greatest numerical coverage at V5/V6 (12.93%) and could produce in theory higher weed control at this growth stage compared to other application parameters tested. Both coverage and droplet density generally decreased with advancing soybean growth stages, closing crop canopy and getting harder penetration. This indicates the need for earlier herbicide applications for optimal weed control, as target pests are more difficult to reach as the canopy develops. At R5, the single-fan MR11003 nozzle oriented in alternating positions created as much coverage as either double-fan nozzle orientation despite the increased canopy growth and MR110015 double fan angled orientation pointed the highest number of droplets. If late applications were required as insecticides or fungicides, these options would be most favorable. Changes in soybean canopy architecture throughout the growing season influenced spray coverage and droplet density. Understanding how nozzle configuration and spray orientation affect deposition at different growth stages may inform application strategies to deliver crop protection products to targeted canopy locations. Further evaluation is needed to determine how these deposition differences translate into biological efficacy for herbicides (where applicable), fungicides, and insecticides.

212 - Cover crops for weed suppression

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[1]University of Nebraska-Lincoln

Cover crops are widely adopted in the North Central region for soil health, nutrient cycling, and erosion control, and they are becoming popular as a weed management tool because of increasing herbicide resistance. Cover crops suppress weeds by competing with winter annual weeds for light, water, and nutrients during fall and spring growth. After termination, their residue blocks light and buffers the soil temperature fluctuations that many weed seeds require to germinate. However, the level of suppression depends on cover crop species, biomass production, and the seed size of the target weed species. The objective of this video is to explain how cover crops suppress weeds and to provide practical guidance for integrating them into corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.] production. It compares cereal rye (*Secale cereale* L.) and hairy vetch (*Vicia villosa* Roth) and explains how they differ in biomass production, residue persistence, and nitrogen contribution. It also shows how growers can evaluate their fallow window, soil moisture, winter survival, and residual herbicide carryover risk before planting. A screen-recorded demonstration of the Midwest Cover Crops Council selector tool shows how to choose cover crop species by location, cash crop growing window, and weed suppression goal. By promoting cover crops as a complement to herbicide programs, this video aims to support more diverse and sustainable integrated weed management strategies.

213 - Making Spray Tip Decisions to Reduce Herbicide Drift

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Looking at a spray tip catalog and trying to decide what spray tip a grower needs can be a confusing decision. Having the proper spray tip for your specific job is critical to the success and effectiveness of a spray application. When choosing a spray tip, drift mitigation is important to ensure that off target herbicide effects are limited, leading to healthy environments and happy neighbors. In this video, researchers at the University of Nebraska Lincoln break down four common spray tip types helping farmers understand how spray tips are classified and which of the four minimizes drift potential the best. An XR 110015, AIXR 110015, a TT 110015, and a TTI 110015 are compared and explained in a way that would be easily understood by growers. Each of the drift reducing technologies present in each spray tip is also discussed. A backpack sprayer and water sensitive paper were used to demonstrate particle size and drift patterns for each spray tip. It was determined that the TTI tip had the largest particle size, indicating the lowest drift potential. This video looks to provide growers with a simple and quick resource to understand spray tip classification and the thought process involved in selecting the correct tip for the spray job. It also educates farmers on the importance of managing drift and following proper spray protocol.

214 - Palmer Amaranth Suppression and Nitrogen Credit from Hairy Vetch in Popcorn

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Nebraska is the leading producer of popcorn (*Zea mays* L. var. *everta* (Sturtev.) L.H. Bailey), growing about 34% of the U.S. supply, roughly one in three bowls eaten nationwide. Yet popcorn has few herbicide options for multiple herbicide-chemistry-resistant Palmer amaranth (*Amaranthus palmeri* S. Watson) control, and high fertilizer prices have increased interest in biological nitrogen sources. Hairy vetch (*Vicia villosa* Roth), a winter-annual legume cover crop, can suppress weeds and fix nitrogen, but guidance on when to terminate it ahead of popcorn is limited. A 2025-2026 field experiment at the South-Central Agricultural Laboratory near Clay Center, Nebraska, evaluated hairy vetch termination timing and herbicide programs for Palmer amaranth suppression and nitrogen supply. The study was a split-plot design with three replications. Main plots were a no-cover-crop check and hairy vetch seeded in October 2025 and terminated at popcorn planting, 3-leaf and 5-leaf stage with mesotrione (105 g ai ha^{-1}) plus atrazine (560 g ai ha^{-1}). Subplots were five herbicide programs: a no-herbicide check; one pass of acetochlor plus atrazine (2,270 plus 1,126 g ai ha^{-1}) at planting; one pass of dicamba (420 g ai ha^{-1}) after emergence; two passes combining both; and two passes with a layered residual, adding encapsulated acetochlor (1,261 g ai ha^{-1}) to the second pass. Palmer amaranth density and biomass were recorded 14, 28, 36, and 42 days after planting. Hairy vetch shoots were sampled before each termination and soil nitrate was measured at 0-5, 5-10, and 10-20 cm. Hairy vetch terminated with mesotrione plus atrazine reduced Palmer amaranth biomass by up to 73% while supplying early-season nitrogen. Averaged across herbicide programs and termination, biomass was 12.9 g m^{-2} without a cover crop and 5.2, 4.3, and 3.5 g m^{-2} with termination at planting, 3-leaf, and 5-leaf stages. Termination timing interacted with herbicide program ($P = 0.029$): in no-herbicide subplots, biomass reduced from 31.2 g m^{-2} without a cover crop to 14.5 and 11.8 g m^{-2} with termination at the 3 and 5-leaf stages. Hairy vetch reduced Palmer amaranth density by 64 to 79%. Herbicide program was the dominant factor ($P < 0.001$): two-pass programs reduced density 89 to 95% relative to the no-herbicide check and the two-pass program with a layered residual was most effective, although its added herbicide cost may concern popcorn growers. Delaying vetch termination from planting to the 3- and 5-leaf stages increased fresh biomass from 1,884 to 2,587 and 3,383 kg ha^{-1} and shoot nitrogen from 29.8 to 42.7 and 52.0 kg ha^{-1}. Soil nitrate (0-20 cm) was 12.6 and 10.7 kg N ha^{-1} with termination at the 3- and 5-leaf stages, about five times the 2.2 kg N ha^{-1} without a cover crop, with about half in the upper 5 cm. Hairy vetch did not replace an effective herbicide program, but terminating it at the 3- to 5-leaf stage and pairing it with a two-pass program can improve Palmer amaranth management and nitrogen supply in popcorn.

215 - Weed Emergence Dynamics Under Tillage and Herbicide Management in High Organic Matter Soils.

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Common purslane (*Portulaca oleracea* L.) and pigweed spp. (*Amaranthus* spp.) are among the most problematic weeds in vegetable production systems on high organic matter soils (>20% organic matter) in Ohio. To manage these weed species, growers primarily rely on glyphosate burndown applications and mechanical control methods such as hand weeding and tillage which are challenged by development of glyphosate-resistant populations, labor shortage, and stimulatory effect of tillage on subsequent weed emergence. Therefore, there is a need to quantify how frequent cultivation used for weed control

influences weed emergence patterns and whether a preemergence herbicide can be utilized to prevent the subsequent weed emergence. Field experiments were conducted in Willard, Ohio, during 2025 and 2026 to evaluate common purslane and pigweed spp. emergence patterns in five management programs: (1) no tillage with no herbicide, (2) tillage with no herbicide, (3) no tillage with pyroxasulfone preemergence (PRE) 118.7 g ai ha^{-1}, (4) tillage with pyroxasulfone PRE 118.7 g ai ha^{-1}, and (5) tillage with pyroxasulfone PRE 118.7 g ai ha^{-1} and glyphosate postemergence (POST) 1,345 g ae ha^{-1}. A randomized complete block design with four replications was used. Tillage and herbicide rearmaments were applied at four-weeks interval and common purslane, and pigweed spp. emergence was counted at weekly intervals. In the absence of herbicide, common purslane emergence was 214 to 311% higher in tillage (468 to 879 plants m^{-2}) than in no tillage (1,473 to 3,618 plants m^{-2}). In 2025, pigweed spp. emergence did not differ between tillage versus no tillage treatment. In 2026, pigweed spp. emergence was 40% higher in tillage (108 plants m^{-2}) than no tillage (77 plants m^{-2}). In the presence of pyroxasulfone PRE 118.7 g ai ha^{-1}, common purslane and pigweed spp. emergence did not differ in tillage versus no tillage treatment. These results indicate that an effective PRE herbicide is needed to prevent new weed seedling emergence from frequent cultivation used for weed control.

NCWSS Student Contest Papers - Weed Biology & Ecology

216 - PRE Herbicides Reduce Weed Diversity and Alter Community Composition More Than Cereal Rye Termination Timing in No-Till Soybean.

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No-till soybean production relies heavily on herbicides for weed control, while cereal rye (*Secale cereale* L.) provides an additional cultural tactic for residue-mediated weed suppression within an integrated weed management framework. However, cereal rye residue and pre-emergence (PRE) herbicides may impose different filters on weed communities, altering the species and functional groups that persist following these management strategies. A field study was conducted in Lexington, Kentucky, during 2024 and 2025 to evaluate the effects of cereal rye residue levels resulting from early and delayed termination and PRE herbicide application on weed community assembly in no-till soybean. The experiment used a split-plot randomized complete block design with four replications. Main-plot treatments consisted of no cereal rye, cereal rye terminated approximately five weeks before soybean planting, and cereal rye terminated at soybean planting (planting green). Subplots received either no PRE herbicide or a premix of chlorimuron + flumioxazin + pyroxasulfone. Cereal rye aboveground biomass was sampled at each termination timing using 0.25-m^2 quadrats. Weed communities were assessed before the early POST (28 d after planting) and late POST (R1-R3) herbicide applications by identifying and counting all weed species within two 2-m^2 sampling areas per plot. Species richness, Pielou's evenness, and Shannon diversity were calculated from species abundance data and analyzed using linear mixed-effects models. Rank-abundance analysis characterized dominant species, PERMANOVA evaluated community composition, and partial

redundancy analysis assessed associations with small-seeded broadleaves, large-seeded broadleaves, annual grasses, and perennials. Delaying cereal rye termination increased biomass from 3.43 to 12.43 Mg ha^{-1} in 2024 and from 0.58 to 3.39 Mg ha^{-1} in 2025. PRE herbicide affected weed diversity at the early POST census in both years ($P < 0.05$ in 2024; $P < 0.001$ in 2025). Community composition was influenced by a cereal rye termination × PRE herbicide interaction in 2024 (PERMANOVA, $P = 0.01$), whereas PRE herbicide was the primary driver in 2025 ($P = 0.002$). Late-season responses were site-year dependent: PRE herbicide altered community composition in both 2024 ($P = 0.008$) and 2025 ($P = 0.01$), whereas cereal rye termination had no detectable effect. In 2025, PRE herbicide also affected species richness ($P = 0.03$) and Shannon diversity ($P = 0.02$). Overall, PRE herbicide consistently altered weed community composition than cereal rye termination, while cereal rye effects varied with residue biomass and became less detectable later in the season. Rank-abundance and functional-group ordination analyses generally indicated greater abundance of large-seeded broadleaves compared to small-seeded broadleaves in PRE-treated communities. Understanding these shifts may therefore improve integrated weed management decisions by helping anticipate which weed groups are likely to persist under different strategies.

217 - How is the Distribution of Germinable Weed Seeds in Soil Influenced by Cropping-System Management?

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A diversified weed management strategy that both prevents weed seed production and reduces the soil seedbank is a best management practice for controlling herbicide-resistant weeds. Long-term field trials were conducted at three locations [Scott (Mississippi), Lonsinger (Kansas), and Gothenburg (Nebraska)] using a split-plot design with three replications. Crop rotation served as the whole-plot factor [continuous corn vs. 2-year rotation (corn-soybean or corn-cotton) and 3-year rotation (corn-soybean-wheat)], while subplots combined tillage systems (strip vs. conventional or conventional vs. no-till) and cover crop regimes (cereal rye [*Secale cereale*] vs. no cover). Soil samples were collected in year 1 in Kansas (baseline) and year 3 in Mississippi and Nebraska across two sampling depths (0-5 cm and 5-10 cm) using five 10-cm diameter cores per plot. Weed seedbank responses varied by location and trial phase. At Scott, MS, a significant tillage × depth interaction was detected for total weed density (P = 0.022). Under strip tillage, weed density was concentrated in the 0-5 cm layer (1,485 vs. 216 seedlings m^{-2} at 5-10 cm), whereas conventional tillage resulted in a more uniform vertical distribution (639 vs. 341 seedlings m^{-2}). At Lonsinger, KS, soil depth influenced weed seedbank vertical distribution. Grass density was higher at 5-10 cm than at 0-5 cm, with 65.8% of grass emergence originating from the deeper soil layer. In Nebraska, total weed density was uniformly distributed between the 0-5 and 5-10 cm soil layers (34.6 vs. 32.1 seedlings m^{-2}). Similarly, broadleaf density did not differ by depth (28.0 vs. 28.8 seedlings m^{-2}). In contrast, grass density was greater in the 0-5 cm layer than in the 5-10 cm layer (6.60 vs. 3.11 seedlings m^{-2}). A significant crop rotation × depth interaction was detected for species richness (P = 0.017), with the greatest richness observed in the 0-5 cm layer of the 3-year rotation. Overall, the results suggest that

tillage primarily influenced the vertical distribution of germinable weed seeds in soil, but this effect will vary across locations in response to regional differences in climate, soil type, and management practices.

218 - Weed Community Assembly in Response to Corn Stature and Weed Control Duration[

Nathan Welch[1], Erin Burns[1]

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Short-statured corn (*Zea mays* L.) hybrids offer advantages such as decreased lodging susceptibility and compatibility with higher planting densities, but how they influence weed community composition remains unclear. Therefore, the objective of this study was to examine if control duration, hybrid stature, and planting population influenced weed community composition and yield compared to a traditional statured hybrid. Studies were conducted in 2025 and 2026 at East Lansing (EL), MI and in 2026 at Hickory Corners (KBS), MI and utilized a randomized complete block designs with four replications. Factorial treatment combinations consisted of: three corn hybrids (traditional, short-upright leaves, short-pendulum leaves), two planting populations (79,000-standard, 99,000-high seeds ha^{-1}), and five weed-free durations (0, 2, 4, 6, 8 weeks). Weed counts by species began one week after each weed-free period ended and continued biweekly until 63 days after planting (DAP). Aboveground weed biomass was collected before corn harvest. Weed density, weed diversity metrics, and grain yield were analyzed using linear mixed-effects models and treatment means were separated using Tukey's HSD in R. Weed community composition was evaluated using PERMANOVA and treatments were separated and visualized in NMDS plots. Yield in EL differed by hybrid by weed-free duration and hybrid by population interactions ($p<0.0001$), where the traditional statured hybrid was more competitive within weed-free durations and yielded more at the standard population. Biomass was affected by weed-free duration and hybrid at EL ($p<0.0001$, $p=0.0438$), and by their interaction at KBS ($p=0.0003$). Overall, weed density was greatest at 0- and 2-week durations and decreased with increasing weed-free durations at both sites ($p<0.0001$). At EL, the main effect hybrid identified traditional hybrid having 23% more weeds compared to the short upright hybrid ($p=0.027$). Weed-free duration consistently influenced diversity metrics although hybrid, population, and their interactions occasionally influenced diversity metrics at different DAP. Species richness, Shannon diversity index, Simpson's diversity index, and species evenness were all altered by the main effect of weed-free duration at EL 63 DAP, species evenness and Shannon's diversity fell within increasing weed-free durations. At KBS weed-free duration affected only species evenness 63 DAP, whereas the hybrid by population interaction influenced species richness, Shannon diversity, and Simpson's diversity indices. The traditional hybrid at the high population had the greatest values for each metric. The PERMANOVA analysis identified the weed-free by hybrid interaction to be a driver of the weed community dissimilarities for both sites ($p<0.0001$). Moreover, NMDS ordinations identified that weed community composition shifted progressively along weed-free duration gradient rather than forming discrete treatment clusters. Both sites showed similar communities at 0-and 2- week durations, and centroids of the following weed-free durations began to shift, identifying community composition separation. Hybrid effects, although less apparent, were visualized once weed-free durations were accounted for. Overall, hybrid specific communities overlapped, but the traditional stature ellipses occupied larger ordination space, and at KBS the traditional stature's centroid laid outside ellipses of

either short hybrid. Collectively, these findings suggest that while weed-free duration determines the overall trajectory of weed community assembly, hybrid stature can influence community composition.

173 - Root Architecture and Morphology of Palmer Amaranth, Waterhemp, and Common Lambsquarters

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Palmer amaranth (*Amaranthus palmeri* S. Watson), waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] and common lambsquarters (*Chenopodium album* L.) are competitive weeds and have evolved resistance to herbicides with multiple sites of action. While numerous studies have focused on shoot growth and above-ground competitiveness, limited research has explored their root biology, despite roots being a principal component for plant stability, resource acquisition and environmental adaptability. The objective of this study was to quantify root architecture, morphology and biomass of these three economically important weed species across growth stages. We conducted a greenhouse experiment in 2025-2026 using lysimeter boxes arranged in a completely randomized design. Plants were fertigated with a 20-20-20 (NPK) solution (15 mL plant^{-1} every 10 days). Destructive root sampling of the weed species was done at 30, 60, 90 and 120 days after sampling (DAS). Roots were washed and analyzed with Win-RHIZO Root Scanner to determine root length, root surface area, root projected area, root volume, average root diameter, and root system architecture metrics (tips, forks, and crossings). Shoots and roots were harvested separately and oven-dried to a constant weight at 75^{0} C. Dry weights were then recorded to quantify shoot dry weight, root dry weight, and total plant dry weight for each treatment. Data were analyzed in R (v4.5.2). Means were separated with Tukey’s HSD ($P \leq 0.05$) using the *e*mmeans and multcomp packages, and trait relationships were summarized with principal component analysis (FactoMineR) and Pearson correlations. Palmer amaranth allocated a greater proportion of its biomass to roots than waterhemp and common lambsquarters, with root mass fractions of 0.38 vs. 0.17 at 30 DAS and 0.20 vs. 0.11 at 60 DAS. Waterhemp was the tallest species at 30 and 60 DAS in both years (at 30 DAS, 0.86 vs. 0.22 to 0.23 m in 2025 and 0.99 vs. 0.56 to 0.76 m in 2026) and had the lowest root branching intensity at 120 DAS (2.4 vs. 4.2 root tips cm^{-1} for common lambsquarters). Common lambsquarters produced the least root dry weight at 30 DAS (4.9 vs. 9.4 to 10.0 g plant^{-1}) and finer roots than Palmer amaranth (0.55 vs. 0.80 mm average root diameter), but its later root growth was strongly year-dependent: root surface area from 60 to 120 DAS was 103 to 169 cm^2 in 2025 but 1,502 to 1,750 cm^2 in 2026, respectively. Root length and number of root tips did not differ among species at any sampling time. These results indicate weed-specific strategies, with Palmer amaranth investing in roots early, waterhemp emphasizing shoot elongation, and common lambsquarters showing the most variable root development between years. Palmer amaranth’s early belowground investment may contribute to its superior drought tolerance and competitive edge under limited resources, highlighting the need for further root-focused studies to develop targeted management strategies.

NCWSS Student Contest Papers – Equipment & Application Methods

219 - On-Farm Evaluation of Herbicide Application Strategies with See & Spray in Soybean

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Targeted herbicide applications can reduce the amount of herbicide applied by spraying only where weeds are present. However, it is important to determine whether these systems can provide effective weed control without increasing soybean (*Glycine max* L.) injury or reducing yield under commercial conditions. On-farm studies were conducted near Belleville and Moundridge, Kansas, in 2025 and 2026 using a John Deere™ See & Spray™ system to compare conventional broadcast, Premium (single-tank targeted), and Ultimate (dual-tank targeted-plus-broadcast) application systems. Herbicide programs followed grower practices and varied by location and year. In both targeted treatments, POST herbicides were applied only where weeds were detected, while the Ultimate system also allowed residual herbicides to be applied broadcast. Fields were divided into replicated strips, with six 4 x 4 m sampling areas established within each strip. Weed control and soybean injury were visually evaluated 1, 2, and 3 weeks after treatment (WAT). Crop chlorophyll content was measured using a SPAD meter, and yield was also evaluated to characterize soybean response. Data were analyzed using ANOVA and Tukey's test. In 2025, weed control exceeded 90% at both locations and did not differ among treatments. In 2026, weed control followed different patterns between locations. At Belleville, control increased from 60% 1 WAT to 85% 3 WAT. At Moundridge, control was 90% 1 and 2 WAT and declined to 70% 3 WAT. Weed control did not differ among the three application strategies at either location. Soybean injury varied among treatments at the early evaluation. At Moundridge in 2025, soybean injury 1 WAT was 18% in broadcast, 6% with single-tank, and 13% with dual-tank. At 2 WAT, injuries were 11%, 2%, and 9%, respectively. In 2026, injury 1 WAT was 20% for broadcast, 11% with single-tank, and 19% with dual-tank at Belleville, while at Moundridge injury was 46% with broadcast and 36% with both targeted treatments. These differences were no longer present by 3 WAT. SPAD responses were similar among application strategies, with most of the variation associated with environment and soybean growth stage. Application strategies did not affect plant height or node number. Yield did not differ among application strategies in any field year. Over the two years, weed control with single-tank and dual-tank applications was similar to broadcast. Differences in soybean injury were observed at early evaluations, but did not persist later in the season, also SPAD, plant height, node number, and yield were similar. These results support targeted herbicide applications to reduce POST herbicide use while maintaining weed control and soybean performance.

220 - Two Technologies, One Target: Electrical Weeding and Spot-Spraying in Orchards

Abraham Akuoko[1], Joshua Miranda[1]

[1]Michigan State University

Michigan ranks third nationally in apple production, with an industry valued at $322 million annually. Effective weed management is essential to orchard productivity, yet conventional programs face challenges from herbicide resistance, crop injury, and off-target movement. Management options for organic growers are limited and costly ($230-$1,445 ha^{-1}), often necessitating soil-disturbing cultivation. These challenges highlight the need for alternative weed management strategies that reduce reliance on herbicides and soil-disturbing practices without compromising weed control. Electrical weed control (EWC) offers a nonchemical approach by delivering high-voltage current through electrodes in contact with weed foliage, while spot-spraying technologies like those from WEED-IT use chlorophyll-detection sensors to actuate nozzles only where green vegetation is detected, potentially reducing herbicide volume input per unit area. However, their combined effectiveness in orchards remains uncertain. In 2026, field experiments were conducted in apple orchards in Holt and Clarksville, MI, to evaluate weed control and herbicide savings. Sixteen treatments were evaluated, consisting of a nontreated control, a broadcast herbicide standard consisting of clethodim (136 g ai ha^{-1}) plus carfentrazone-ethyl (35 g ai ha^{-1}), EWC alone, and various combinations of EWC with WEED-IT spot-spraying or broadcast herbicide applications. Four application timings were used throughout the growing season, beginning in May and spaced eight weeks apart. Electrical treatments were applied using a Zasso eWeeding Roller at energy doses of 13.4 and 6.7 kJ m^{-2}, achieved by adjusting operating speeds to 0.8 and 1.6 km h^{-1}, respectively. WEED-IT was used for targeted herbicide applications. Weed control and weed cover were assessed at 2, 4, and 8 weeks after each application, and herbicide spray volume was measured during each application. At the end of the growing season, four weeks after the final application, three programs integrating EWC and spot-spraying provided 83% to 87% dandelion (*Taraxacum officinale* L.) control at Clarksville, exceeding the 50% control achieved with the broadcast-only program. At Holt, programs integrating EWC and spot-spraying provided 50% to 86% dandelion control, compared with 61% for the broadcast-only program. Across locations, grass (*Poaceae*) control ranged from 51% to 85%, with the broadcast-only program achieving 85% control, whereas EWC-only and selected lower-energy EWC and spot-spraying programs provided significantly lower control (≤55%). At Holt, nontreated plots had 49% weed cover, significantly greater than most treated programs; at Clarksville, weed cover ranged from 17% to 30%, without significant differences among programs. Increasing EWC energy from 6.7 to 13.4 kJ m^{-2} did not significantly improve weed control. Most notably, weed management programs integrating EWC with spot-spraying reduced cumulative herbicide volumes by up to 79% compared to broadcast spraying while generally providing comparable weed control. Overall, integrating EWC and spot-spraying substantially reduced herbicide volume and effectively controlled several important orchard weeds. However, control varied among weed species and treatment programs, highlighting opportunities to further optimize these technologies. Future research will evaluate the cost-benefit and return on investment of integrating these technologies into orchard weed management programs.

221 - Italian Ryegrass (*Lolium perenne* ssp. *multiflorum*) Control Using UAV-Based Herbicide Applications.

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Control of Italian ryegrass (*Lolium perenne* ssp. *multiflorum*) has become increasingly difficult in many fields across western Kentucky over the last few decades due to resistance to multiple modes of action. During the spring months, timely field access can be limited, making effective burndown applications challenging. The goal of this study was to evaluate the efficacy of reduced spray volumes applied using an unmanned aerial application system for Italian ryegrass control. A field in western Kentucky that was in winter fallow after a double-crop soybean was used to conduct an application study in the spring of 2026. A single factor study was arranged in a randomized complete block design with four replications. A DJI T10 unmanned aerial vehicle (UAV) applied glyphosate at three different spray volumes: 9, 23, and 47 liters per hectare (L ha^{-1}), while an ATV-mounted sprayer applied one treatment at 140 L ha^{-1} to represent a ground application. An untreated control was also included. Evaluations from this study included percent coverage, number of droplet deposits, visual control, and Italian ryegrass biomass and density at 28 days after treatment (DAT). Results found that the 140 L ha^{-1} ground applied treatment resulted in significantly greater percent spray coverage and number of droplets compared with the UAV treatments. Percent coverage did not differ significantly among the three UAV application treatments. However, the 9 L ha^{-1} treatment resulted in significantly fewer droplet deposits than the 23 and 47 L ha^{-1} treatments. In comparison to the untreated control, Italian ryegrass density was lower only in the 140L ha^{-1} ground application treatment, whereas the three UAV treatments did not differ from the untreated density. There were no significant differences in the 28 DAT live Italian ryegrass biomass among the spray volume treatments, and all were significantly lower than the untreated check. Visual evaluations at 28 DAT indicated that the 140 L ha^{-1} ground application treatment had the highest visual control, however it was similar to the 23 and 47 L ha^{-1} UAV treatments. These results indicate that while there is significantly greater coverage and droplet deposition by the 140 L ha^{-1} ground application treatment, ryegrass biomass and density at the 9, 23, and 47 L ha^{-1} spray volumes applied by the UAV did not significantly lower efficacy as compared to the 140 L ha^{-1} ground application. Although, visual evaluations indicate that the 9 L ha^{-1} UAV application did reduce efficacy as compared to the 140 L ha^{-1} ground application. This provides evidence that the lower application volumes of 23 and 47 L ha^{-1} applied by unmanned aerial vehicles may provide Italian ryegrass control comparable to a conventional ground-based application, despite differences in spray coverage.

222 - A New Electric Approach to Redroot Pigweed (*Amaranthus retroflexus*) Control in Carrots

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[1]Michigan State University

Michigan ranks fourth nationally in carrot production, but slow crop establishment and a long growing season create an extended period for weed interference. Redroot pigweed (*Amaranthus retroflexus*) is problematic because of its rapid growth, high competitive ability, limited herbicide options, and increasing herbicide resistance. Electrical weed control (EWC) is a nonchemical alternative that could complement herbicides and reduce hand-weeding labor. A study was conducted in Hart, Michigan, in 2026 to determine the effects of EWC energy dose, number and timing of passes, and preemergence (PRE) herbicides on redroot pigweed control. The experiment was arranged in a randomized complete block split-plot design with four replications. Each block contained three main plots receiving pendimethalin (1,120 g ai ha^{-1}), *S*-metolachlor (1,070 g ai ha^{-1}), or pendimethalin + *S*-metolachlor. Subplots received combinations of three EWC energy doses: 56, 28, and 14 kJ m^{-2}, achieved by adjusting operating speeds to 1.2, 2.4, and 4.8 km h^{-1}, respectively; and three application programs: one pass at the 2-leaf carrot stage; two passes at the 2- and 5-leaf stages; or three passes at the 2-, 5-, and 10-leaf stages. The first EWC application therefore occurred at the 2-leaf stage. Electrical treatments were applied with a tractor-mounted Zasso™ EH30 unit. Weed assessments were conducted 14, 28, 40 and 58 days after the initial EWC treatment (DAIT). Weed density and biomass were measured separately within the carrot row (in-row) and between adjacent carrot rows (between-row) to evaluate EWC performance by zone. We recorded hand-weeding time to quantify labor required to remove remaining weeds. Carrot stand and yield were determined at harvest. At 58 DAIT, in-row redroot pigweed density was affected by the number of passes. In-row density declined from 12.2 weeds m^{-2} with one pass to 4.2 and 4 weeds m^{-2} with two and three passes, respectively. In contrast, between-row redroot pigweed density was affected by PRE herbicide and number of passes, decreasing from 9.3 weeds m^{-2} with one pass to 3.3 and 4 weeds m^{-2} with two and three passes, respectively. Increasing the number of passes also reduced in-row biomass, while between-row biomass was affected by both EWC energy dose and passes. Two and three passes reduced between-row biomass by 85% and 87% compared with one pass. Energy doses of 56 and 28 kJ m^{-2} resulted in 59% and 54% less between-row biomass than 14 kJ m^{-2}. Improved weed control also reduced hand-weeding from 38 h ha^{-1} with one EWC pass to 23 and 20 h ha^{-1} with two and three passes, respectively. At harvest, PRE herbicide program and number of EWC passes affected carrot stand. However, these differences did not reduce carrot yield. In conclusion, repeated EWC applications improved redroot pigweed control and reduced hand-weeding time without affecting carrot yield. Two passes were as effective as three, while energy doses of 28 and 56 kJ m^{-2} outperformed 14 kJ m^{-2}. EWC may support integrated weed management in carrots, though further research should assess its consistency across environments and economic return.

223 - Comparison of Solinftec Solix Autonomous Targeted Applications with Conventional Broadcast Applications for Weed Control, Herbicide Volume Savings, and Grain Yield

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The Solinftec® Solix is an autonomous, solar-powered robotic targeted sprayer. This technology has the potential to reduce herbicide use and labor requirements by eliminating the need for an on-site operator during applications. The objective of this study was to evaluate weed control, herbicide savings, and grain yield impacts from the Solix compared with conventional broadcast applications. The field experiment was conducted in 2026 in West Lafayette, Indiana following a randomized complete block design with nine treatments and four replications. The Solix treatments included: 1) a preemergence (PRE; 174 g a.i. ha^{-1} sulfentrazone + 22.1 g a.i. ha^{-1} cloransulam-methyl + 1070.5 g a.i. ha^{-1} *S*-metolachlor) followed by (fb) a single postemergence (POST; 369.9 g a.i. ha^{-1} glufosinate-P-ammonium + 1,261 g a.e. ha^{-1} glyphosate) targeted application, 2) a PRE fb two targeted POST applications, 3) no PRE fb constant targeted POST applications (once per week), and 4) a PRE fb constant targeted POST applications. The conventional broadcast treatments consisted of 1) a PRE fb a single POST application and 2) a PRE fb two POST applications, with the first POST including an overlapping residual herbicide (glufosinate + glyphosate with 118.7 g a.i. ha^{-1} pyroxasulfone + 17.6 g a.i. ha^{-1} cloransulam-methyl). A seventh treatment comprised a combination of a broadcast PRE, fb a broadcast POST with an overlapping residual herbicide, fb a late targeted POST application. Additional treatments consisted of a nontreated control and a weed-free, hand-weeded control. Visual assessments of weed control and density counts (two 0.25-m^2 quadrats within each plot), waterhemp (*Amaranthus tuberculatus*) and giant foxtail (*Setaria faberi)*, were conducted at harvest. Postemergence herbicide a.i. reductions were calculated using Solix generated spray reports to determine % area and spray volume. Subsequently, the applied herbicide a.i. was calculated and compared to the total area. Grain was harvested with a Kincaid 8-XP combine, harvesting the middle 3m of each plot. Visual control and weed density count data were analyzed using generalized linear mixed models (ANOVA) in R Studio 2026.1.0.392 using R Version 4.5.2. Yield analysis is ongoing. Following a PRE and a broadcast POST application with an overlapping residual, targeted and broadcast late POST applications averaged 98% visual waterhemp control and zero waterhemp plants. Giant foxtail visual weed control and weed density counts were not statistically significant. Incorporating a targeted late POST after a PRE fb a broadcast POST with an overlapping residual reduced glufosinate-P-ammonium and glyphosate use by 48% (g a.i. and a.e. ha^{-1}) compared with the same program using a broadcast late POST. A PRE fb a single targeted POST application reduced herbicide use by 8% relative to a PRE fb a single broadcast POST application. These results suggest that a Solinftec® Solix autonomous targeted sprayer may be a viable component in integrated weed management strategies when combined with broadcast PRE herbicides, overlapping residuals, and other suppressive strategies, as targeted POST applications alone may require more frequent applications, reduce efficiency, and increase herbicide resistance risk.

224 - A UAV-Enabled Decision Support Framework for Predicting Weed Mortality and Guiding Soybean Respray Applications

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Timely identification of herbicide treatment failures is critical for effective weed management and respray decision-making in soybean [*Glycine max* (L.) Merr.] production. Traditional visual assessments are labor-intensive, subjective, and often delay management interventions until treatment failures become apparent. Unmanned aerial vehicles (UAVs) may offer an opportunity to monitor weed responses shortly after herbicide application and support objective management decisions. A field study was conducted at the Throckmorton Purdue Agricultural Center in Lafayette, Indiana during the 2025 and 2026 growing seasons to evaluate UAV-derived imagery for predicting weed mortality and supporting soybean respray decisions. The experiment was arranged as a randomized complete block design with four replications. Seven herbicides (2,4-D, glufosinate-ammonium, paraquat, clethodim, fomesafen, cloransulam-methyl, and glyphosate) were applied at two rates: full (labeled) and half. Volunteer corn [*Zea mays* L.] and giant ragweed [*Ambrosia trifida* L.] served as target weed species. A DJI Mavic 3M and 3T were flown at 22 m (1 cm pixel^{-1}) and 12 m (1.58 cm pixel^{-1}) above ground level, respectively, at 1, 3, 5, 9, and 14 days after application (DAA) to acquire RGB, multispectral, and thermal imagery. Orthomosaics were generated in Pix4Dfields (v2.9.4) and processed in ArcGIS Pro (v3.5.0) to develop species-specific masks for volunteer corn and giant ragweed through supervised classification. These masks were used to isolate target weed canopies and extract spectral and thermal features, including normalized difference vegetation index (NDVI), normalized difference red-edge index (NDRE), green normalized difference vegetation index (GNDVI), modified chlorophyll absorption ratio index (MCARI), leaf chlorophyll index (LCI), soil-adjusted vegetation index (SAVI), canopy temperature, and the within-canopy standard deviation of each variable. All statistical analyses were conducted in R (v4.4.0). Species-specific spectral and thermal features, including NDVI, NDRE, GNDVI, MCARI, LCI, SAVI, herbicide-response group information, and associated variability metrics were used as predictors in random forest models to estimate final giant ragweed and volunteer corn mortality. Receiver operating characteristic (ROC) analysis was subsequently used to identify spectral thresholds associated with respray recommendations based on an 80% mortality criterion. Random forest models successfully explained variation in final giant ragweed mortality, accounting for approximately 63%, 68%, 71%, and 75% of observed variability at 1, 3, 5, and 9 DAA, respectively. Volunteer corn mortality prediction was highly accurate as early as 3 DAA ($R^2 = 0.87$), indicating that even with a systemic herbicide like clethodim, mortality and respray decisions can be made within 3 DAA utilizing remote sensing tools. ROC analysis identified a giant ragweed MCARI threshold of 0.016 at 3 DAA (87% sensitivity, 81% specificity) and a volunteer corn MCARI threshold of 0.016 at 5 DAA (85% sensitivity, 100% specificity) for identifying plots that failed to achieve 80% final mortality at 21 DAA. These results demonstrate the potential of species-specific UAV analytics to support rapid herbicide efficacy assessment and guide soybean respray decisions within days of application.

225 - Assessing Nozzle Suitability for Targeted Bioherbicide Spray Systems Applications for Specialty Crops

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The use of conventional and bioherbicides for weed control in specialty crops remains challenging due to limited guidance on optimal application parameters. Limited information on optimal application parameters can reduce application efficiency, increase herbicide overuse, increase crop phytotoxicity, and raise production costs. This highlights the need for ongoing research to refine application parameters and enhance decision-making. This study aimed to develop recommendations on the influence of nozzle type and spray solution on droplet size distribution, drift potential and spray coverage for commonly used conventional and bio-based non-selective herbicides, including water (as a standard), ammonium nonanoate, caprylic and capric acids, eugenol, clove and cinnamon oils, d-limonene, and pelargonic acid, for potential application in specialty crops. For the study, DX4003, ER40-03, TP4003, TP4003E, MHC4004, and MGA4004 were evaluated in a low-speed wind tunnel for droplet size distributions at 276 kPa. Spray solutions were mixed with food-grade blue dye (3g L^{-1}), and kromekote cards were sprayed in a spray chamber calibrated to deliver 374 Lha^{-1} to visualize spray deposition percentage. Results demonstrated significant interactions between the nozzles and solutions. The DX nozzle produced droplets ranging from very coarse to extremely coarse, while maintaining driftable fines below 2.5% across all spray solutions. As anticipated, the hollow-cone nozzles MHC and MGA generated smaller droplets (238 to 295 µm) and a higher proportion of driftable fines (8.5 to 19.8%). Notably, an exception was observed with ammonium nonanoate, where the same nozzles produced ultra-coarse droplets (>800 µm) and relatively low driftable fines (5.7 to 6.2%), suggesting an undesirable interaction between the nozzle and the solution's physical properties. Furthermore, spray solutions containing clove oil and cinnamon oil, and d-limonene consistently showed driftable fines below 9% across all nozzle types, compared with water, indicating consistent drift-reduction potential across tested combinations. In terms of spray coverage, deposition percentage from the TP4003E nozzle was statistically similar and above 90% within all spray solutions. Pelargonic acid showed the highest coverage (90% to 99.8%) across all nozzles, with 99.8% as the maximum among all tested combinations. These findings provide a foundation for practical recommendations to help growers select nozzle-by-solution combinations with good coverage, improve application efficiency, minimize off-target movement, and reduce the risk of crop injury and herbicide overuse in specialty crop production systems.

226 - Dicamba and Glufosinate with Drift-Reducing Agents: Weed Control and Crop Safety

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Product labels for dicamba applications in dicamba-tolerant soybean require the inclusion of drift-reducing agents (DRAs) to mitigate off-target spray drift. The effect of DRA selection on droplet size, weed control, and crop safety may vary. Thus, it is important to evaluate how different DRAs affect these parameters. The objective of this study was to evaluate the effects of four DRAs including methylated seed oil (MSO), crop oil concentrate (COC), high surfactant oil concentrate (HSCOC), and high surfactant methylated seed oil (HSMSO), all applied at 0.3% v v^{-1}, combined with dicamba 560 g a.e. ha^{-1}, and glufosinate-P-ammonium 370 g a.i. ha^{-1}, separately or together on weed control and crop safety. Crop safety and weed control were tested on dicamba-tolerant soybean (*Glycine max* (L.) Merr) at V6 stage and velvetleaf (*Abutilon theophrasti* Medicus) (10 to 13 cm of height) in a three-nozzle (PSLDMQ2004) spray chamber with a 3.54 m s^{-1} traveling velocity and 50.8 cm nozzle spacing, calibrated to deliver 140 L ha^{-1} at 276 kPa. Velvetleaf and soybean plants were assessed and harvested at 28 and 21 days after application, respectively, and dried at 55 °C to a constant weight before determining dry biomass and calculating biomass reduction. Data were analyzed using ANOVA to evaluate the effect of herbicides, adjuvant, and experimental run, as well as their interactions. All treatments containing dicamba and dicamba+glufosinate provided greater velvetleaf control across DRAs (> 90% of control) compared with glufosinate alone (73%). Dicamba+glufosinate treatments had greater biomass reduction (> 98%) compared to dicamba-only treatments (up to 97 %). Across herbicides, adding MSO resulted in greater overall control (90%). For velvetleaf biomass reduction, a significant herbicide by DRA interaction was observed, although DRA effects did not differ in dicamba treatments. Overall, spray additives had minimal effects on visual control but influenced plant biomass reduction, with a significant three-way interaction for soybean biomass reduction indicating differences between experimental runs. In Run 2, HSCOC with dicamba (37 %) and COC with dicamba + glufosinate (35 %) resulted in greater biomass reduction. In Run 1, the corresponding treatments resulted in 31 % and 37 % biomass reduction, respectively, with no differences among adjuvants within herbicide treatments. In conclusion, adding glufosinate to dicamba improved weed control and biomass reduction, while DRAs had minimal effects on soybean crop response. However, differences in biomass reduction between experimental runs suggest that further evaluation is needed to better understand the effects of DRAs on crop response across different treatment combinations.

NCWSS Student Paper Contest – Herbicide Applications for Weed Management – Session 2

227 - Influence of Temperature, Relative Humidity, and Time of Day on the Efficacy of Glufosinate, 2,4-D, and Their Mixture for Waterhemp Control

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Waterhemp (*Amaranthus tuberculatus*) remains a major challenge in Iowa corn and soybean production due to its widespread resistance to multiple herbicide groups, limiting effective postemergence control options. Glufosinate and 2,4-D are important for managing waterhemp in soybean systems with appropriate herbicide-tolerance traits, however, their efficacy is influenced by environmental conditions at application. Previous studies have often examined the effects of temperature and relative humidity (RH) separately. However, temperature and RH vary simultaneously under field conditions, highlighting the need to investigate their interactive effects across a broad range of environmental conditions. This study evaluated the effects of temperature, RH, and application time on waterhemp control with glufosinate, 2,4-D, and their mixture. A controlled-environment study was conducted in a randomized complete block design with four replications and two experimental runs. Treatments consisted of five temperatures (18, 22, 26, 30, and 34°C), five RH levels (30, 45, 60, 75, and 90%), two application times (1:00 p.m. and 10:00 p.m.), and three herbicide treatments: glufosinate (223 g ai ha^{-1} + 3.36 kg ha^{-1} AMS), 2,4-D (532 g ae ha^{-1}), and their mixture (223 g ai ha^{-1} + 532 g ae ha^{-1} + 3.36 kg ha^{-1} AMS). Plants were initially grown in a growth chamber maintained at 34°C and 60% RH before being transferred to treatment chambers for acclimatization under the assigned temperature plus RH combinations for 48 h before herbicide application. Herbicides were applied during the day or night at 140 L ha^{-1} using a single TP80015EVS nozzle at 241 kPa. Following herbicide application, plants remained under the treatment environmental conditions for 24 h before returning to the main growth chamber. Visual waterhemp control (0-100%) and aboveground dry biomass reduction relative to the nontreated control were assessed at 21 days after treatment (DAT). At 21 DAT, Daytime applications provided greater control than nighttime applications for glufosinate (71.0% vs. 62.5%), 2,4-D (44.7% vs. 38.6%), and their mixture (86.9% vs. 80.5%). Glufosinate application provided ≥80% waterhemp control at temperatures ≥22°C with 90% RH, ≥30°C with 75% RH, and 34°C with 60% RH. Lower temperature and RH combinations generally resulted in <80% control. In contrast, 2,4-D provided less than 80% control across all temperature and RH combinations, with the highest control (68.8%) at 34°C and 90% RH. For the glufosinate + 2,4-D mixture, the effect of temperature did not significantly depend on RH. For the glufosinate + 2,4-D mixture, waterhemp control was ≥80% at temperatures ≥22°C when averaged across RH levels and at RH ≥60% when averaged across temperatures. Glufosinate reduced aboveground dry biomass by 94.8% or greater at 90% RH and when temperature was 22°C or greater. For 2,4-D, the greatest biomass reduction occurred at temperatures greater than 30°C and RH greater than 75%. The glufosinate + 2,4-D mixture resulted in biomass reduction greater than 83% across all temperature and RH combinations. These findings demonstrate that glufosinate efficacy is influenced by both temperature and RH, emphasizing the importance of considering weather conditions when applying glufosinate alone or mixed with 2,4-D to improve postemergence waterhemp control.

228 - Asian Copperleaf (*Acalypha australis*) Response to Soybean Herbicides

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Asian copperleaf (*Acalypha australis*) is an invasive summer annual broadleaf weed in the Euphorbiaceae family that has recently been reported in Iowa row-crop fields and neighboring states. These infestations are the first observations in row crops in the US, and with limited knowledge about biology and management, research is needed to understand impacts and control practices. Its rapid spread and potential competitiveness in soybean production require effective management strategies. This study evaluated the efficacy of standard pre-emergence (PRE) and post-emergence (POST) herbicides for controlling Asian copperleaf in soybean. Field experiments were conducted in Buchanan County, Iowa, during 2026 to evaluate PRE or POST herbicide efficacy. PRE treatments included flumioxazin (0.219 L ha^{-1}), pyroxasulfone + carfentrazone (0.840 L ha^{-1}), metribuzin (1.754 L ha^{-1}), chlorimuron (210.1 g ha^{-1}), sulfentrazone (0.877 L ha^{-1}), pendimethalin (3.506 L ha^{-1}), pyroxasulfone(0.365 L ha^{-1}) and a non-treated control. POST treatments included lactofen (0.914 L ha^{-1}), acifluorfen (1.753 L ha^{-1}), fomesafen (1.753 L ha^{-1}), chloransulam (21 g ha^{-1}), imazethapyr (0.292 L ha^{-1}), chlorimuron (52.5 g ha^{-1}), bentazon (2.37 L ha^{-1}), flumiclorac (0.438 L ha^{-1}), fluthiacet (0.066 L ha^{-1}), and a non-treated control. Separate randomized complete block design trials with four replications were established to evaluate PRE and POST herbicide programs. Weed control was visually assessed relative to a non-treated control 28 days after treatment (DAT). Herbicide treatments differed significantly in Asian copperleaf control. Data were analyzed using one-way ANOVA, and treatment means were separated using Tukey’s HSD test at a 0.05 significance level. Among PRE herbicides, chlorimuron provided the greatest control (>90%), followed by sulfentrazone and flumioxazin. Pendimethalin was the least effective PRE treatment, providing less than 15% control. PRE herbicides generally offered limited season-long suppression because substantial weed emergence continued throughout the growing season. Among POST herbicides, lactofen and fomesafen provided the highest levels of control (>90%). Acifluorfen also provided effective control, whereas chloransulam, imazethapyr, bentazon, flumiclorac, and fluthiacet provided poor to moderate suppression. Results indicate that chlorimuron was the most effective PRE option for early-season Asian copperleaf suppression, while lactofen and fomesafen were the most reliable POST herbicides for controlling established infestations. The study demonstrates that season-long management of Asian copperleaf in soybean will likely require integrated herbicide programs that combine effective pre- and post-applications. Continued evaluation of herbicide programs across environments is needed to support recommendations for managing this emerging weed species in Midwest soybean production systems.

229 - The Influence of Tillage and Application Timing on Residual Weed Control and Soybean Response from Diflufenican

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Effective management of *Amaranthus* species is a major challenge in soybean (*Glycine max* (L.) Merr.) production, partially due to widespread herbicide resistance, which highlights the need for soil-residual herbicides with alternative modes of action. Diflufenican, a phytoene desaturase (PDS) inhibitor, is a new soil-residual herbicide, but the efficacy of diflufenican can vary with environmental conditions and crop management practices. Field research was conducted in 2025 and 2026 to determine: 1) how tillage system and herbicide application timing influence weed control from diflufenican (150 g ai ha^{-1}), and 2) how these factors influence soybean injury, using flumioxazin (76 g ai ha^{-1}) as a commercial comparison.

Experiments were conducted as a split-plot design with four replications, with tillage (reduced-till and no-till) as the main plot and herbicide and application timing (preplant and preemergence) as subplots. Herbicides were applied using a 2-m wide handheld boom, calibrated for a spray volume of 140 L ha^{-1} at 172 kPa. Visual estimates of crop injury were assessed at 14, 21, 28, 35, and 42 days after planting (DAP), while weed counts and aboveground biomass were collected at 28 and 42 DAP. Data were analyzed by year using linear mixed models, and means were separated using Tukey’s Honestly Significant Difference test (α=0.05). Weed control differed by year and corresponded with the timing of rainfall after application. In 2025, approximately 9 cm of rain was received within 8 days after the preplant application, and diflufenican reduced weed biomass by 17% (reduced-till) and 66% (no-till) at 42 DAP, while preemergence applications reduced biomass by 98 to 100%. In 2026, the first significant rainfall event (6 cm) occurred 15 days after preplant and 8 days after preemergence applications. Preplant applications of diflufenican reduced biomass by 99 to 100% in 2026, whereas preemergence applications in no-till were lowest for both herbicides (84 to 85%). Soybean injury (bleaching, necrosis, and stunting) was greatest 14 DAP in 2026, when injury from diflufenican reached 44% following preemergence applications in tilled plots, compared with 14% in no-till but flumioxazin followed a similar pattern (40% and 12%). Crop injury from preplant applications of diflufenican was 28% (reduced-till) and 10% (no-till) in 2026, and injury did not exceed 15% in 2025. Across years, preemergence applications resulted in more consistent diflufenican efficacy than preplant applications. However, flumioxazin efficacy in terms of weed biomass reduction was more consistent across years (81 to 100%) than diflufenican (17 to 100%). These results suggest that the interval between herbicide application and the first substantial rainfall may influence diflufenican performance more than total rainfall. Overall, diflufenican exhibited potential for residual *Amaranthus* control in soybean, although application timing and tillage should be considered to balance weed control with soybean tolerance.

230 - Impact of fall-applied flumioxazin on Amaranthus control the subsequent growing season

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Waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] is a problematic weed in Illinois cropping systems due to its extended emergence period and widespread herbicide resistance profile. In addition, the application of fall pre-emergence herbicides to improve weed control during the subsequent growing season has long been an important topic in grain production across the state. Therefore, a bare-ground field trial was established in the fall of 2025 and evaluated through the spring of 2026 at one site in Champaign County, Illinois, to evaluate the effectiveness of fall applications of flumioxazin, a Group 14 herbicide, for controlling waterhemp during the 2026 growing season. This study revisits previous research and evaluates different rates of the active ingredient flumioxazin using a linear rate structure (35, 70, 105, and 140 g ai/ha). The trial was arranged as a randomized complete block design with three replications, with individual plots measuring 3 × 9 m (27 m^2). To evaluate the effectiveness of this strategy compared with a conventional management program involving a spring-applied herbicide, a mixture of S-metolachlor and metribuzin was applied at rates of 1,471 g S-metolachlor/ha and 350 g metribuzin/ha as a pre-emergence herbicide to half of all plots in early April 2026 to simulate a

conventional spring herbicide program. Of the 30 plots in the experiment, three received no herbicide applications and served as untreated checks, while another three received the fall burndown treatment but did not receive flumioxazin. All remaining plots received the same fall burndown treatment consisting of 2,4-D ester (780 g ai/ha), glyphosate (667 g ai/ha), and ammonium sulfate (1,385 g ai/ha), with flumioxazin rates being the only variable among treatments.

231 - Soybean Response to Mesotrione Across Different Herbicide-Tolerant Cultivars

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Corn (*Zea mays* L.) and soybean (*Glycine max* (L.) Merr.) are commonly grown in rotation across Nebraska, and farmers often use the same spray equipment for herbicide applications on both crops. Inadequate cleanout procedures may leave residual herbicide, leading to unintended crop injury and possibly reduced yield. This study aims to evaluate how soybean cultivars with different herbicide tolerance traits respond to sub-labeled mesotrione applications to characterize dose-response relationships and the potential consequences of unintended exposure. The dose-response experiment included four different herbicide-tolerant cultivars, and these are glyphosate, glufosinate, 2,4-D, and dicamba-tolerant soybean cultivars, along with two non-herbicide-tolerant cultivars. Mesotrione was applied at seven doses, from 0.20 to 315.24 g ai ha^{-1}, corresponding to 1/512×, 1/128×, 1/32×, 1/8×, 1/2×, 1×, and 3× of the reference rate (105.08 g ai ha^{-1}), to evaluate soybean responses across a wide range of herbicide exposure levels when the herbicide is applied at the third true trifoliate. Applications were made using a single DG9502EVS nozzle at 276 kPa, calibrated to deliver 140 L ha^{-1} at a travel speed of 1.35 m s^{-1}. The nozzle was positioned 30.5 cm above the plants. Plant biomass was harvested 21 days after application (DAA), dried at 49 °C for 10 days or until a constant weight was reached, and then weighed to determine dry biomass. Dose-response analysis of dry biomass showed a nonlinear increase in biomass reduction with increasing mesotrione doses. Estimated ED_{10} values ranged from 0.92 ± 0.33 g ai ha^{-1} for one of the assessed non-herbicide-tolerant cultivars to 2.49 ± 0.47 g ai ha^{-1} for the 2,4-D-tolerant cultivar, while ED50 values ranged from 12.13 ± 1.50 g ai ha^{-1} for the 2,4-D-tolerant cultivar to 26.08 ± 3.54 g ai ha^{-1} for the dicamba-tolerant cultivar. At the highest tested dose of 315.24 g ai ha^{-1}, dry biomass reduction was around 76 to 82% across the used cultivars. Findings indicate that unintentional mesotrione exposure caused various crop injuries depending on soybean herbicide-tolerant traits. These results may help explain damage risks from sprayer contamination or off-target movement based on soybean variety sensitivity, especially at doses below the recommended field rate.

232 - Environmental Conditions and Adjuvants Influence Glyphosate Efficacy in Common Lambsquarters (*Chenopodium album*)

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Common lambsquarters (*Chenopodium album* L.) is a problematic weed in corn, soybean and sugar beet production systems across the Upper Midwest, with some populations reported to show reduced sensitivity to glyphosate recently. Glyphosate efficacy may be influenced by several factors involving environmental conditions, herbicide formulation, and adjuvant selection. The objectives of this research were to evaluate the effects of temperature and relative humidity (RH) on glyphosate efficacy and determine whether commercially available adjuvants improve glyphosate efficacy in population with reduced sensitivity. Experiments were conducted using three common lambsquarters populations: one with suspected reduced sensitivity to glyphosate collected from a farmer's field in Bathgate, North Dakota (referred to as "BG" here), and two known glyphosate-susceptible populations (FK - collected from a farmer's field in Franklin, MN; and GRIN - obtained from USDA-ARS Germplasm Resources Information Network). Glyphosate dose-response bioassays were conducted in controlled-environment chambers under four combinations of temperature and RH conditions: [high temperature-high humidity (HT-HH), high temperature-low humidity (HT-LH), low temperature-high humidity (LT-HH), and low temperature-low humidity (LT-LH)]. A subsequent experiment evaluated glyphosate absorption in BG and FK under low and high RH conditions, while another experiment compared the efficacy of glyphosate applied alone or with nonionic surfactant (NIS), crop oil concentrate (COC), methylated seed oil (MSO), or high-surfactant crop oil concentrate (HSCOC). The BG population showed reduced glyphosate efficacy under low-RH conditions. Under both HT-LH and LT-LH conditions, fitted aboveground biomass reduction in BG remained below 80%, even at four times the labeled glyphosate rate, whereas the susceptible FK and GRIN populations exceeded 80% biomass reduction. Glyphosate absorption differed between BG and FK at 6 and 12 hours after treatment under low RH, whereas differences under high RH were observed only at 12 hours. Glyphosate absorptions were generally higher under high RH than low RH. At the labeled glyphosate rate (1,260 g ae ha^{-1}), Roundup PowerMAX3 (K-salt) and Cornerstone 5 Plus (IPA-salt) provided comparable biomass reduction in FK, whereas Cornerstone provided lower biomass reduction than Roundup PowerMAX3 in BG. Addition of COC to Cornerstone lowered biomass reduction in both populations, while NIS, MSO, and HSCOC resulted in biomass reduction statistically comparable to Roundup PowerMAX3 in BG. Results from this study showed that lower RH reduced glyphosate efficacy in the reduced-sensitive BG population. The BG population responded differently to glyphosate formulations, but adding NIS, HSCOC, or MSO improved glyphosate control at the labeled rate, whereas these adjuvants provided no additional benefit in FK.

Horticulture, Specialty Crops, Turf and Ornamentals

233 - Integrated Energy-Based Weed Control: Preliminary Results from Combined Electric and Laser Treatments in Specialty Crops

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Electric weed control (EWC), using over-the-row spark-discharge weeders have been evaluated for weed control and adopted for use in both agronomic and horticultural commodities, especially in organic production. Manufacturers are currently developing continuous-contact systems designed to manage weeds between crop rows, providing opportunities for earlier intervention without cultivation. A trial was established on 16 July 2026 at Cornell AgriTech in Geneva, NY, to evaluate the performance and safety of continuous-contact EWC combined with another thermal weed control tool, laser weeding, in transplanted tomato (*Solanum lycopersicum* L.) and direct-seeded sweet corn (*Zea mays* L.), soybean (*Glycine max* (L.) Merr.), snap bean (*Phaseolus vulgaris* L.), hemp (*Cannabis sativa* L.), and red beet (*Beta vulgaris* L.). Treatments included a nontreated check (NTC), between-row cultivation (CULT, using a tractor-powered rototiller), between-row EWC (using a tractor-powered Zasso E*Coffee unit), CULT plus in-row laser-weeding (LASER, using a tractor-powered Carbon Robotics G200 unit), and EWC plus LASER. LASER treatments occurred on 26 July and 5 August; CULT and EWC treatments occurred on 11 August. Dominant weeds at the site were common lambsquarters (CHEAL, *Chenopodium album* L.), Powell amaranth (AMAPO, *Amaranthus powellii* S. Watson), and common purslane (POROL, *Portulaca oleracea* L.); annual grasses were sparse throughout the site. Weed counts (both between and in the crop rows) were collected weekly through August. Weed and crop biomass were harvested from each plot approximately 90 days after planting, when weed cover and the presence of flowering or seed-producing weeds were also recorded. Weed responses were primarily driven by control treatments. Averaged across crops, the CULT plus LASER and EWC plus LASER treatments maintained 70-97% fewer in-row weeds than NTC across assessments from 3-24 August, with counts 87-96% and 62-95% lower than CULT and EWC alone, respectively. Following CULT and EWC applications, between-row weed counts were 47-81% lower than NTC at assessments on 17 and 24 August. Percent weed cover at harvest was 10, 2, 33, 15, and 50% in the CULT and EWC plus LASER treatments, CULT, EWC, and NTC treatments, respectively. Reproductive weeds were observed in 100% of NTC plots, 96% of CULT and EWC plots, 67% of CULT plus LASER plots, and 25% of EWC plus LASER plots. Relative to NTC within each crop, CULT plus LASER and EWC plus LASER, averaged together, had 94-99.9% less in-row weed biomass at harvest. Between-row weed biomass was 95-99.7% lower in hemp, soybean, beet, sweet corn, and snap bean, whereas the tomato reduction was only 4.5%. Averaged across crops, EWC plus LASER had the lowest between-row weed biomass (2.03 g per 0.25 m^2), compared with 13.52 g under CULT plus LASER and 274.56 g in NTC. Beet shoot and root biomass per plant differed among treatments, with the highest means under EWC plus LASER. An exploratory contrast indicated 32% greater aboveground crop biomass per plant when a LASER treatment was included, averaged across CULT and EWC and the six crops. These results indicate that targeted in-row laser weeding combined with between-row EWC offers a promising approach to weed management with reduced reliance on cultivation. Further research is needed to determine whether the observed increases in crop biomass translate into greater marketable yields.

234 - Breaking the Regrowth Cycle: Electrical Weed Control in New Jersey Highbush Blueberries

Tong Zhen[1], Aleah Butler-Jones[2], Luke Mackara[1], Lynn Sosnoskie[2], Thierry Besançon[1]

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Electrical weed control (EWC) is an emerging nonchemical weed management tool that could be integrated with herbicide programs in blueberry production. The tractor-mounted EWC unit used in this study was manufactured by Zasso™. Field experiments were conducted in 2025 and 2026 in an established 6-year-old highbush blueberry planting at the Rutgers P.E. Marucci Center in Chatsworth, NJ, using a randomized complete block design with four replications. Five weed management programs were evaluated: (1) EWC alone (three applications in 2025 and two in 2026); (2) a preemergence (PRE) herbicide program plus glufosinate (Rely 280; 1,147 g ai ha^{-1}) followed by (*fb*) EWC (two EWC applications in 2025 and one in 2026); (3) the PRE program plus tiafenacil (Gamma; 74 g ai ha^{-1}) *fb* EWC (two EWC applications in 2025 and one in 2026); (4) the PRE program *fb* glufosinate (Rely 280; 984 g ai ha^{-1}), applied twice in both years; and (5) an untreated weedy control. The PRE program consisted of flumioxazin (Chateau SW; 214 g ai ha^{-1}) plus S-metolachlor (Dual Magnum; 1,068 g ai ha^{-1}). Across both years, all weed management programs generally reduced weed cover at the berm edge relative to the untreated control. In 2026, preapplication goldenrod density differed significantly among treatments, with lower densities in the EWC-alone and PRE plus glufosinate *fb* EWC programs than in the untreated control, potentially reflecting carryover effects from the 2025 treatments. At 21 days after the first application in 2026, goldenrod density was significantly lower in the EWC-alone program and the programs integrating EWC with glufosinate or tiafenacil than in the untreated control. All weed management programs significantly reduced total weed dry biomass at the berm edge compared with the untreated control in both years. In 2026, the PRE *fb* glufosinate herbicide program significantly increased marketable yield relative to the untreated control in both Elliott and Bluecrop. No significant treatment effects on marketable yield were detected in either cultivar in 2025. These findings indicate that EWC can effectively suppress weeds in blueberry production, particularly when integrated with chemical weed management.

235 - Evaluating Bicyclopyrone Tank Mixtures for Weed Control in Fall Broccoli Production

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Bicyclopyrone is an HPPD-inhibiting herbicide recently registered for use in preemergence weed-control programs in broccoli and other vegetable crops. Field studies were conducted at the University of Maryland Wye Research and Education Center in Queenstown, MD, to evaluate broccoli tolerance, yield, and weed control following applications of bicyclopyrone at 0.44 or 0.51 g ha^{-1} combined with S-

metolachlor at 13.9 g ha^{-1}, with or without flumioxazin at 1.4 g ha^{-1}. Liquid ammonium sulfate (2.5% v/v) and a nonionic surfactant (0.25 % v/v) were included with bicyclopyrone treatments. Bensulide at 67.3 g ha^{-1} and a nontreated check were also included. Three production systems were evaluated: transplanted broccoli grown on plastic mulch, transplanted broccoli grown on bare ground, and direct-seeded broccoli grown on bare ground. Studies were arranged in a randomized complete block design with four replications. Flumioxazin-containing treatments caused the greatest broccoli injury, particularly in the bare-ground transplant system. At 48 days after application, stunting reached 35% in that system, whereas all other treatments caused less than 3% stunting. In the plastic mulch system, injury was less than 10% across treatments by 48 days after application. In the bare-ground transplant system, flumioxazin-containing treatments reduced yield to 3,443 heads ha^{-1} and 818 kg ha^{-1}, compared with 8,302 heads ha^{-1} and 2,559 kg ha^{-1} for the low-rate bicyclopyrone plus S-metolachlor treatment, bensulide, and the nontreated check. In the plastic mulch system, the low-rate bicyclopyrone plus S-metolachlor treatment produced greater harvested weight (3,385 kg ha^{-1}) than the corresponding treatment containing flumioxazin (2,084 kg ha^{-1}). Bicyclopyrone treatments provided excellent control of smooth pigweed (*Amaranthus hybridus* L.), carpetweed (*Mollugo verticillata* L.), common purslane (*Portulaca oleracea* L.), and morningglory species (*Ipomoea* spp.). Control was generally greater than that provided by bensulide. Goosegrass (*Eleusine indica* [L.] Gaertn.) control exceeded 95% in all treatments in the bare-ground systems, whereas bensulide provided only 40% control in the plastic mulch system. Herbicide program selection affected broccoli injury and yield, particularly in bare-ground transplanted broccoli. Although bicyclopyrone-based programs provided broad-spectrum weed control, flumioxazin-containing programs reduced crop safety and yield under some production conditions. Herbicide programs should therefore be selected according to the specific broccoli production system.

236 - Preemergence Herbicide Timing in Field Nursery Systems

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Preemergence (PRE) herbicides can be applied year-round in field-grown nursery crops, but application timing is often scheduled around other nursery tasks and available labor. As a result, weed control is reduced and nurseries must rely on postemergence herbicides or manual weed removal which can be time consuming and expensive due to fuel and labor costs. The objective of this project was to evaluate weed control efficacy of several PRE herbicides applied at different times of the year. Herbicides (flumioxazin, indaziflam, isoxaben + prodiamine, and pendimethalin + simazine) were applied in September, December, and May to separate plots within nursery rows. Non-treated plots were included as a control for each application timing. Experiments were conducted at three nurseries with differing weed populations (two in North Carolina and one in Tennessee). In May following the September and December applications, weed coverage was 20 (pendimethalin + simazine) to 58% (indaziflam) lower for all PRE herbicides compared to the non-treated plots. In June, weed coverage for the September applications ranged 28 (indaziflam) to 69% (pendimethalin + simazine). December applications were more effective and weed coverage ranged 20 (indaziflam) to 50% (pendimethalin + simazine). PRE applications made in May provided 50% or greater weed control through August for all PRE treatments. Overall, indaziflam provided the longest residual weed control followed by flumioxazin. Based on these results, two PRE

applications per year could provide excellent weed control and would be made prior to or following nursery crop harvesting or planting to avoid labor availability issues.

237 - Evaluating Weed Control and Herbicide Efficiency in Snap Bean using an Ecorobotix Ultra High Precision Sprayer

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Weed management in processing snap beans (*Phaseolus vulgaris*) in the northeastern US typically relies on a limited number of preemergence (PRE) and postemergence (POST) herbicides. Vision-guided targeted sprayers, such as the Ecorobotix ARA, offer opportunities to reduce herbicide inputs while maintaining weed control and crop safety. Field trials were established in 2026 at Cornell AgriTech (Geneva, NY) and the Rutgers Agricultural Research and Extension Center (Bridgeton, NJ) to compare targeted and broadcast herbicide application programs. All herbicide-treated plots received *S*-metolachlor PRE at 800 g ai ha^{-1}, except the sequential ARA treatment in NJ, which received 535 g ai ha^{-1}. Broadcast POST applications at 23 and 19 days after planting (DAP) in NY and NJ consisted of bentazon at 600 g ai ha^{-1} in NY and 842 g ai ha^{-1} in NJ, each combined with fomesafen at 279 g ai ha^{-1}. ARA applications also included tank mixtures of bentazon and fomesafen. Three ARA programs were evaluated at each location: sequential POST applications at T1 and T3, a single POST application at T2, and a rescue POST application at T3 (NY) or T4 (NJ). Application timings T1-T3 corresponded to 23, 34, and 42 DAP in NY; T1-T4 corresponded to 13, 19, 27, and 43 DAP in NJ. Additional treatments included PRE alone and a nontreated check (NTC). Weed cover and density were assessed throughout the season. Weed biomass, flowering weed escapes, and crop responses were evaluated at harvest, which was 62 DAP in NY and 55 DAP in NJ. Weed cover in the single and sequential ARA programs was similar to that for the broadcast program throughout the season, ranging from 1-8% in NY and <1-5% in NJ. In the rescue ARA programs, weed cover reached 13% at 59 DAP in NY and 38% at 49 DAP in NJ. In NY, all ARA programs and the broadcast program reduced weed biomass by ≥98% relative to the NTC. In NJ, the single and sequential ARA programs and the broadcast program reduced weed biomass by ≥97%, compared with 87% for the rescue ARA program. Poorer performance of the NJ rescue program may have reflected larger weeds at application and reduced spray deposition because of canopy closure. At harvest, the rescue ARA programs at both locations and the sequential ARA program in NY had more flowering weed escapes (0.3-0.5 weeds m^{-1}) than the broadcast programs (0.03-0.08 weeds m^{-1}), suggesting a potential tradeoff between reduced spray inputs and the prevention of weed reproductive escapes. In NJ, ARA programs produced total crop biomass (1.5-1.8 kg m^{-1}) and marketable bean yield (0.6-0.8 kg m^{-1}) comparable to those of the broadcast program. Yield comparisons in NY were confounded by excessive precipitation and subsequent crop stunting. Compared with broadcast applications, ARA programs reduced spray volume by an average 54% for the sequential POST, 68% for the single POST, and 71% for the rescue POST applications. These results support single, but early, and sequential targeted POST applications as options for reducing spray volume while maintaining weed suppression, with comparable marketable yield.

238 - Does Rolling Improve Early-Season Weed Control in Dry Bulb Onion

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Onion cannot tolerate prolonged weed competition and has repeatedly been shown to have a strong negative correlation between relative yield and the duration of weed competition. In fact, one study reported that of the 27 crop species tested, onion was the least competitive against weeds. Much of the research conducted at NDSU has investigated early-season weed control since the lack of weed control at this stage can cause total crop loss. Preliminary research in 2025 showed that rolling plots after planting onion increased the uniformity of weed control, making early-season weed control achievable. The objective of this project is to determine if rolling the soil in combination with appropriate herbicide applications prior to onion seedling emergence will keep the field generally weed-free until the onion reaches the two-true-leaf stage, when numerous products are available. The current study evaluated the 12 highest yielding treatments from 2025 that included the weed-free control and made applications to rolled and non-rolled plots. Two onion cultivars (Delgado and Legend) were direct-seeded on May 1. The PRE treatments were applied six days after planting (DAP), the delayed PRE treatments were applied 22 DAP and the early POST treatments were applied at the flag leaf stage, 38 DAP. The two-leaf POST applications occurred 55 DAP, while the four-leaf POST applications occurred 69 DAP and the six-leaf POST applications occurred 82 DAP. There was a 23% increase in the number of emerged weeds in the rolled hand-weeded control compared to the non-rolled hand-weeded control. On August 17, the last day of hand-weeding, rolled plot averaged 21 weeds per plot, three times more than non-rolled plots. Early-season weed control evaluation occurred 52 DAP, just prior to applications at the two-true-leaf stage. At 52 DAP, glyphosate applied delayed PRE followed by pendimethalin at flag leaf gave significantly lower common lambsquarters control than all other treatments, on both rolled and non-rolled ground. Pigweed control was likewise lowest with this program. However, it was lower on non-rolled ground than on rolled ground. At 66 DAP, onion injury was highest (>60%) when bicyclopyrone was applied at the two-true-leaf stage regardless of rolling. All other treatments averaged ≤ 8.5% injury, but was still greater than the hand-weeded plots. Onion yield and grades are still being analyzed and will be discussed at the meeting. The study will be repeated in 2027.

239 - Evaluating Laser Weeding for Weed Control, Crop Safety, and Operational Efficiency in Cilantro, Spinach, and Kale

Thierry Besancon[1], Luke Mackara[1], Lynn Sosnoskie[2], Valerie Alvarez[3]

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Weed management in specialty crops is challenging because of limited herbicide options, potential crop injury, and successive weed emergence throughout the growing season. Laser weeding uses computer vision and artificial intelligence to identify and eliminate weeds without herbicides or soil disturbance. Three field trials were conducted in spring 2026 at the Rutgers Agricultural Research and Extension

Center in Bridgeton, NJ, to evaluate weed control, crop tolerance, productivity, and operating efficiency of the Carbon Robotics LaserWeeder G2 in direct-seeded cilantro (*Coriandrum sativum* L.), spinach (*Spinacia oleracea* L.), and kale (*Brassica oleracea* L. var. *acephala*). Treatments included a nontreated control (NTC), preemergence (PRE) herbicide alone, PRE followed by postemergence (POST) herbicide, laser alone, and PRE followed by laser. Spinach also included POST alone. Herbicide programs consisted of prometryn (1.68 kg ai ha^{-1}) PRE followed by linuron (0.56 kg ai ha^{-1}) POST in cilantro; *S*-metolachlor (0.72 kg ai ha^{-1}) PRE followed by phenmedipham (0.55 kg ai ha^{-1}) POST in spinach; and napropamide (1.12 kg ai ha^{-1}) PRE followed by clopyralid (0.105 kg ae ha^{-1}) POST in kale. Four laser applications were made in cilantro. At harvest, weed biomass was 330 g m^{-2} in the NTC, compared with 3.1 and 0.5 g m^{-2} with laser alone and PRE followed by laser, respectively. Marketable yield was 12,161 and 15,748 kg ha^{-1} under these programs, compared with 2,122 kg ha^{-1} in the NTC. Although PRE followed by laser produced the highest numerical yield, differences among weed management treatments were not significant. Adding PRE reduced cumulative laser operating time by approximately 70%. In spinach, three laser applications maintained weed cover at no more than 4% at harvest and reduced weed biomass by at least 99% relative to the NTC. Laser treatments maintained crop stands, whereas broadcast phenmedipham reduced stand density by approximately 60%. Maximum temperatures reached 36°C, including three consecutive days near 36°C following POST application, exceeding the 24°C label threshold and likely contributing to severe crop injury. Marketable yield was 10,598-11,516 kg ha^{-1} under laser programs, compared with 6,381 kg ha^{-1} in the NTC and no more than 1,017 kg ha^{-1} under phenmedipham programs. In kale, three laser applications reduced weed density by 84-96% immediately following treatment. At harvest, weed density was 356 weeds m^{-2} in the NTC, compared with 125 and 44 weeds m^{-2} with laser alone and PRE followed by laser, respectively. Weed biomass was 469, 19, and 1 g m^{-2}, respectively. Marketable leaf weight increased from 132 g $plant^{-1}$ in the NTC to 347-372 g $plant^{-1}$ under laser programs, with minimal crop injury. Adding PRE reduced laser operating time by 52% and 46% during the second and third applications, respectively. These results show that laser weeding can provide effective season-long weed suppression while maintaining crop tolerance and productivity in cilantro, spinach, and kale. In spinach, laser weeding also provided an alternative to POST herbicides associated with severe crop injury under high temperatures. Combining laser weeding with residual PRE herbicides improved weed suppression in kale and substantially reduced operating time in cilantro and kale. These savings could improve the economics of laser weeding, although equipment costs and commercial field capacity will need to be considered.

240 - Relative Herbicide Safety in Selected Vegetable Crops

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Vegetable producers are concerned about crop injury from soil-applied herbicides and the potential for yield reductions. Over the years, UD Weed Science has evaluated herbicides for crop safety and weed control. However, when weed control is less than excellent, it can be difficult to distinguish crop stunting and yield reductions caused by herbicide injury from those resulting from weed competition. In 2025 and 2026, studies evaluated potential herbicide injury in pea (*Pisum sativum* L.), cantaloupe (*Cucumis melo* L.), snap bean (*Phaseolus vulgaris* L.), sweet corn (*Zea mays* L. var. *saccharata*), and sweet corn grown

on black plastic. Commonly used herbicides for each crop were applied at normal use rates and at two or three times the labeled rate. To eliminate the potential effects of weed competition, plots were either treated with an effective postemergence herbicide or handweeded. Crops were evaluated for injury following emergence, and most crops were harvested to assess yield and yield components. Herbicide injury varied among crops and years. In peas, pendimethalin and clomazone injury was observed only in 2025. In cantaloupe, halosulfuron caused significant crop stunting in both years. Halosulfuron also caused the greatest injury in snap bean, with symptoms persisting for four weeks after emergence and resulting in reduced yields in 2026. In sweet corn, pyroxasulfone applied at the higher rate caused the greatest injury in 2025, whereas no injury was observed in 2026. Soil-applied herbicides have the greatest potential to cause crop injury when planting occurs early and growing conditions are less than ideal. Understanding these potential risks will help vegetable producers make more informed weed management decisions.

241 - Postemergence Herbicides for Perennial Weed Control in Field Grown Peony Cut Flowers

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Peony (*Paeonia lactiflora*) is a popular herbaceous perennial cut flower crop, emerging in early spring with harvest in spring to early summer. Hedge bindweed (*Calystegia sepium*), an herbaceous perennial weed spreading by fleshy roots and seeds, is particularly problematic in peony production fields. Shoots emerge in the spring at about the same time as peony stems, then twine up the floral stem. At harvest, vines must be hand-removed, increasing harvest labor processing time by up to 45 seconds per stem. Effective means of controlling hedge bindweed in the spring before harvest would decrease harvest and processing costs. In conjunction with the USDA IR-4 program, a series of experiments were conducted on a 125-acre in-ground peony farm in Pantego, NC, and at the Horticulture Field laboratory in Raleigh NC. At the on-farm site peony plants were grown in 40-inch rows with 24-inch in-row spacings. In one test, directed sprays (contacting the lower one-quarter of the peony canopy) of 0.125, 0.25 or 0.5 lb ai/A of Lontrel T&O (clopyralid) and broadcast (over-the-top) applications of 1, 2 or 4 oz/A of Grapple (rimsulfuron) were applied to in-ground *Paeonia lactiflora* ‘Sarah Bernhardt’. In the same field, directed applications of the 1X and 2X doses of Lontrel and Grapple were evaluated for plant safety to *Paeonia lactiflora* ‘Phyllis Kraus’ and efficacy on hedge bindweed. Weedar 64 (2,4-D amine) at 1 lbai/A was included for comparison. Separately, the safety and efficacy of directed applications of 4, 8, or 16 oz/A mesotrione (Callisto) and 1.25, 2.5 or 5 oz/A sulfosulfuron (Certainty) were evaluated. Applications commenced on March 30, 2026, and were repeated on May 8, 2026 in Pantego, and April 9 and May 20 in Raleigh. Over the top applications of Grapple or Certainty to actively growing peonies caused persistent general chlorosis, stunting, and a 45% to 87% reduction in flowering. Conversely, directed applications resulted in only minor chlorosis of contacted foliage. Grapple at 2 oz/A provided 60% to 69% bindweed control; Certainty at 1.25 oz/A provided 75% control. Directed applications of Lontrel at 0.125 lb ai/A caused no injury in one experiment and some minor, temporary epinasty in the 2nd study. At 0.25 lb ai/A, injury to ‘Sarah Berhnardt’ peony was $\leq$ 10%; 8% to 23% on ‘Phyllis Kraus’ but did not reduce flower yield, and achieved >90% bindweed control. Directed applications of 2,4-D amine controlled bindweed but caused greater injury to peony stems. Callisto applications caused significant

bleaching and foliar necrosis when applied to actively growing peony plants. Directed applications of Lontrel, Grapple, or Certainty have potential for suppression of hedge bindweed and other susceptible perennial weeds in field grown cut flower peony production if minor foliage discoloration or epinasty can be tolerated.

242 - Optimizing seed treatments and tank mixtures to safen herbicides in green onion

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Abstract not available.

Invasive Weeds, Rangeland, Pasture and Vegetation

243 - Response of Field-grown Sweetpotato to Herbicides.

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Three field studies were conducted to determine the effect of four pre-transplant (PRE) and twelve post-transplant (POST) herbicides on 'Covington' sweetpotato tolerance, yield, and quality in North Carolina in 2025 and 2026. Herbicides were applied at recommended field rates. PRE herbicides were applied PRE the day of transplanting (0 DAT) while POST herbicides were applied 2 wk after transplanting (2 WAT). Data collected included sweetpotato foliar injury rated on a scale of 0% to 100% with 0% being no injury and 100% equal to plant death 2, 3, 4, 6, and 10 WAT for PRE and POST treatments with an additional rating 2.5 WAT for POST treatments. Sweetpotato storage roots were harvested 14 to 16 WAT and graded by hand into canner, no. 1, and jumbo grades. Total yield was recorded as the sum of all grades while marketable yield was the sum of no. 1 plus jumbo. The interaction between treatment and study was significant ($P \leq 0.0001$) therefore data were analyzed by study. Across all studies, visual foliar injury from sethoxydim (315 g ai ha^{-1}) POST, clomazone (1,260 g ai ha^{-1}) PRE, fluridone (168 g ai ha^{-1}) PRE, halosulfuron (26 g ai ha^{-1}) PRE, and linuron (560 g ai ha^{-1}) PRE was ≤ 3% at all rating dates. In contrast, 2,4-D (532 g ai ha^{-1}), glyphosate (1681 g ai ha^{-1}), glufosinate (450 g ai ha^{-1}), and atrazine (1793 g ai ha^{-1}) caused sweetpotato death in one or more studies. Foliar injury from paraquat (579 g ai ha^{-1}) was ≥ 50% at 2.5 WAT across all studies. However, by 10 WAT injury was ≤ 5%. Linuron (560 g ai ha^{-1}), halosulfuron (26 g ai ha^{-1}), clomazone (1260 g ai ha^{-1}), and carfentrazone (1.4 g ai ha^{-1}) POST resulted in ≤ 18%, ≤ 24%, ≤ 16%, and ≤ 18% injury 3 WAT respectively across all studies. By 10 WAT injury was ≤3%. Injury

from bentazon (840 g ai ha^{-1}) and metribuzin (420 g ai ha^{-1}) ranged from 22 to 48% and 19 to 78% 3 WAT, respectively. By 10 WAT injury from bentazon and metribuzin was ≤ 5%. No storage roots were harvested from 2,4-D and glyphosate across all studies. In addition, no storage roots were harvested from atrazine and glufosinate in at least one study. In at least one study atrazine, glufosinate, metribuzin, and paraquat reduced total yield compared to the nontreated check. Atrazine, bentazon, halosulfuron POST, and paraquat reduced marketable yield in at least one study compared to the nontreated check.

244 - Postemergence Herbicide Programs for Bosc's Mille Graines Control in St. Augustinegrass and Zoysiagrass Sod Production

Venkateswar Reddy Yelkur[1], Navdeep Godara[1], Brooke Heikkila[1], Gram Grant[1]

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Bosc's mille graines (*Oldenlandia boscii*) is a perennial broadleaf weed in the Rubiaceae family, which can reduce turfgrass aesthetics and sod quality. Other Rubiaceae weeds, such as poorjoe (*Diodia teres*) and Virginia buttonweed (*Diodia virginiana*) are difficult-to-control in turfgrass and often require sequential applications of synthetic auxin-based herbicide mixtures. However, information on selective postemergence (POST) control of Bosc's mille graines (BMG) in turfgrass is limited. Four field experiments were conducted in Council, NC, in 2025 and 2026 to evaluate the effect of synthetic auxin-based herbicide programs on BMG control, weed biomass, and tolerance of 'Sola' St. Augustinegrass and 'Empire' zoysiagrass. Trials were conducted in sod production fields infested with BMG with treatments arranged in randomized complete block design with four replications. Treatments included a nontreated control, carfentrazone + triclopyr, dicamba + metsulfuron premix, dicamba + mesotrione + triclopyr premix, triclopyr, 2,4-D + dicamba + mcpp premix, 2,4-D + dicamba + mcpp + carfentrazone, 2,4-D + carfentrazone + dicamba + dichlorprop premix, 2,4-D + dicamba + penoxsulam + sulfentrazone premix. All herbicides applied sequentially at four-week interval, except 2,4-D + dicamba + mcpp premix. Responses were analyzed separately by turfgrass species. Triclopyr- and 2,4-D + dicamba + mcpp premix containing treatments provided >84% BMG control and reduced weed biomass >81% at 12 weeks after initial treatment (WAIT). 2,4-D + dicamba + mcpp premix and triclopyr-containing treatments caused >28% St. Augustinegrass injury, while only dicamba + mesotrione + triclopyr premix caused >20% injury to zoysiagrass at 8 WAIT. Turfgrass cover was not affected by herbicide treatments at 8 WAIT, showing transient herbicide injury. 2,4-D + dicamba + mcpp + carfentrazone offers acceptable BMG control with minimal injury to St Augustinegrass and zoysiagrass. Future research will focus on optimizing herbicide application timings and developing nonchemical tactics for BMG management.

Integrated Weed Management and Cover Crops

245 - Planting Green: A Weed and Water Management Tool.

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Planting and managing cover crops can affect agroecological processes, altering soil moisture and weed population dynamics. Planting green, a cover cropping tactic in which a cover crop is terminated at or after cash crop planting, has been evaluated as a weed management tool, but the interactive effects of weed and water dynamics using this technique are not well studied. Additionally, the marginal benefits of planting green over early cover crop termination on the number of spring field working days (FWDs) and in-season water availability have yet to be addressed. One objective of the collaborative GROW Legacy project was to investigate soil moisture and weed suppression dynamics across multiple soybean (*Glycine max*) producing regions of the United States. The experimental design was a single factor randomized complete block design with the following levels: no cover crop, cereal rye (*Secale cereale*) terminated two to three weeks prior to soybean planting, and rye terminated at soybean planting (e.g., planting green). Our experimental design was replicated in four blocks at two sites at each of the nine GROW Legacy collaborator locations for three years. Weed demography data were collected 28 days after soybean planting (28 DAP) and separated into small- and large-seeded species categories. Soil moisture and temperature data were collected in 15-minute intervals from spring thaw until harvest, though due to equipment limitations, this data was only taken in one block within each site at each of the locations per year. Soil moisture was converted into a binary success or failure of a field working day (FWD) before soybean planting and a binary success or failure of a drought free day (DFD) after soybean planting. Additionally, a difference in soil water storage (SWS), soil temperature, and soil temperature amplitude was calculated between the cover crop and no cover crop treatments between planting and 28 DAP. These variables were then regressed linearly against cereal rye biomass generated by each site. Piecewise structural equation modeling (pSEM) was used to related cereal rye biomass, SWS, soil temperature, and soil temperature amplitude to weed recruitment 28 DAP. As cover crop biomass increased, both spring FWD and season long DFD increased. Increasing cover crop biomass also increased SWS and decreased soil temperature and temperature amplitude. However, pSEM revealed that none of these soil environmental variables significantly affected weed recruitment 28 DAP when combined with cover crop biomass. Instead, cover crop biomass significantly reduced small-seeded weed recruitment 28 DAP without mediation by soil variables but had no significant effect on large-seeded weed populations.

246 - Influence of Travel Speed and Path Geometry on Spatial Accuracy of a Machine Vision Sprayer for Annual Bluegrass Control

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Machine-vision sprayers can reduce herbicide use in turfgrass by treating only detected weeds, but field accuracy may depend on travel path and speed. Two experiments evaluated the Ecorobotix ALBA sprayer in dormant bermudagrass [*Cynodon dactylon* (L.) Pers.]. In the first, annual bluegrass (*Poa annua* L.) transplants were sprayed with a dye tracer at 2.7 or 6.3 km h^{-1} along straight or curved paths. The split-

plot randomized complete block design had four replications and three runs, with path geometry as the main plot and speed as the subplot. Images of 20 weeds per unit quantified offsets between weed and spray centroids, weed and spray area, and weed hit rate. Curved paths increased the distance between weed and spray centers (1.3 to 7.3 cm), expanded spray area (109 to 181 cm^2), and reduced weed hit rate (99 to 92%). Spray coverage was 8.5 (straight) and 12.5 (curved) times greater than weed coverage. Travel speed did not affect targeting accuracy but slightly increased spray coverage, depending on trial. In the second experiment, a randomized complete block design (two trials, four replications) on a fairway compared broadcast and machine-vision applications of glufosinate or glyphosate at 1,128 and 788 g ae ha^{-1}, respectively. Additional machine-vision treatments applied each herbicide at 1,656 g ae ha^{-1}, alone or with indaziflam at 33 g ai ha^{-1}. Spray coverage on indigenous weeds averaged 3.5 times weed coverage, less than the 8.5 times fold expansion on transplants, with a 96% weed hit rate across treatments. At 56 d after treatment (DAT), glyphosate controlled annual bluegrass 98% and reduced density 95%, regardless of rate, admixture, or application method. Glufosinate averaged 54% control and 53% density reduction. Bermudagrass treated at 5 to 10% greenup showed reduced cover and dark green color index (DGCI) at 7 and 14 DAT when herbicides were broadcast. Machine-vision applications therefore conserved turf green color by limiting bermudagrass exposure. These results demonstrate that machine-vision sprayers can lower herbicide use and cost, with path geometry influencing spray placement more than speed. Future work should expand machine-vision evaluations to additional turfgrass species and weeds and evaluate repeat applications of targeted organic herbicides to improve control.

247 - Determining Weed Density Thresholds for Machine Vision-Guided Targeted Herbicide Applications in Bermudagrass

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Annual bluegrass (*Poa annua* L.) is a troublesome winter annual weed in managed turfgrass systems. Targeted application sprayers (TAS) utilize artificial intelligence and machine vision to identify weeds and deliver herbicides precisely to weeds, potentially reducing herbicide inputs while improving application efficiency. Previous research reported that herbicide saving from TAS was driven by weed cover but conducted under simulated weed densities. A field experiment was conducted in Raleigh, NC, in 2026 to investigate the influence of annual bluegrass cover levels and herbicide programs on TAS application efficiency, spray volume reduction and weed control in hybrid bermudagrass fairways. The experiment was arranged as two-factor factorial (herbicide program × weed cover) in randomized complete block design with four replications. Herbicide programs consisted of glufosinate (2,800 g ha^{-1}) + flumioxazin (420 g ha^{-1}) as nonselective treatment and three sequential applications of methiozolin (1,580 g ha^{-1}) as selective treatment. Targeted applications were evaluated at annual bluegrass cover levels of 0.5%, 1%, 2%, 5%, 10%, 20%, and 30% and compared with broadcast applications. Treatments were applied using ALBA (Ecorobotix Inc.) at 400 L ha^{-1} and 3.5 km hr^{-1}. At annual bluegrass cover of ≤10%, TAS achieved application efficiency >25-fold compared to broadcast spraying while reducing spray volume by ≥80%, regardless of herbicide program. Glufosinate + flumioxazin applications were three times more efficient than the methiozolin program and provided 98% annual bluegrass control

compared to 86% with methiozolin at 14 weeks after initial treatment. Precision, recall, and F-score were ≥0.79 when annual bluegrass cover was ≥2%. Results indicate that TAS is most efficient at effectively managing annual bluegrass infestations between 2 and 10% cover while substantially reducing herbicide inputs. Future investigations will evaluate TAS performance across additional site years and determine application thresholds for perennial rhizomatous weeds, including purple nutsedge (*Cyperus rotundus* L.).

248 - Targeted vs. Broadcast Application: Conserving Herbicide with Ecorobotix ARA Sprayer in Cabbage

Marian Hollenbeck[1], Robert Cooley[2], Katerina Lee[2], Luke Mackara[1], Beth Ferguson[1], Lynn Sosnoskie[3], Thierry Besançon[1]

[1]Rutgers University, [2]Ecorobotix, [3]Cornell University

Herbicides remain important for weed management in vegetable crops, but concerns about crop injury, application costs, off-target movement, and herbicide resistance have increased interest in precision spraying technologies. This study evaluated weed control and crop safety with the Ecorobotix ARA Sprayer™ compared with conventional broadcast herbicide application in cabbage. A field trial was conducted at the Rutgers Agricultural Research and Extension Center in Bridgeton, NJ, using a randomized complete block design with four replications and six treatments. Treatments included a nontreated control (NTC), bensulide applied preemergence (PRE) alone, and four programs combining PRE bensulide with postemergence (POST) herbicides. These included one targeted application of oxyfluorfen + clopyralid at 35 and 13 g ai ha^{-1}, respectively (SpotCon1); two targeted applications of oxyfluorfen + clopyralid at 46 and 13 g ai ha^{-1}, respectively (SpotCon2); one targeted application of caprylic + capric acid at 8% v/v (SpotOrg); and one broadcast application of oxyfluorfen + clopyralid at 35 and 13 g ai ha^{-1}, respectively (BroadCon). Targeted applications were made using the Ecorobotix ARA Sprayer™. The first POST application was made on September 9, 2026, when weeds were at the 2- to 4-leaf stage, followed by a second application in SpotCon2 on September 25. At 7 days after the first POST application (7 DAS1), between-row weed density averaged 56, 49, and 37 weeds m^{-2} in BroadCon, SpotCon1, and SpotCon2, respectively, compared with 109 in SpotOrg, 144 in PRE, and 229 in the NTC. Within-row densities followed a similar pattern, ranging from 27 to 63 weeds m^{-2} among the oxyfluorfen + clopyralid programs, compared with 122 in SpotOrg, 130 in PRE, and 203 in the NTC. At 7 DAS2, following the second application in SpotCon2 only, between- and within-row weed densities were lowest in SpotCon2 (14 and 24 weeds m^{-2}, respectively), compared with 38 and 46 in SpotCon1 and 44 and 72 in BroadCon. Weed density in SpotOrg increased to 187 weeds m^{-2} between rows and 245 weeds m^{-2} within rows. At 68 days after transplanting (DATP), total weed fresh biomass was lowest in SpotCon2 (32 g m^{-2}), followed by BroadCon (195 g m^{-2}) and SpotCon1 (247 g m^{-2}). In contrast, SpotOrg had considerably greater weed biomass (2,190 g m^{-2}), approaching that of the NTC (3,081 g m^{-2}) and PRE (3,117 g m^{-2}). Visual crop injury ratings for leaf curling and twisting averaged 63% with BroadCon, significantly greater than the 10-15% observed with SpotCon1 and SpotCon2. Chlorosis ratings averaged 58% with BroadCon, compared with 15% and 13% in SpotCon1 and SpotCon2, respectively. No chlorosis was observed in the remaining treatments. These results indicate that targeted oxyfluorfen + clopyralid applications reduced crop injury compared with broadcast spraying. Targeted oxyfluorfen + clopyralid applications provided effective weed suppression with less crop injury than the broadcast

treatment. Two targeted applications resulted in the lowest numerical weed densities and biomass, while a single targeted application provided weed suppression numerically similar to broadcast spraying. In contrast, the targeted caprylic + capric acid program provided less persistent weed suppression. These findings suggest that herbicide selection and application frequency are important considerations when using precision spraying technologies in cabbage. Further evaluation is needed to quantify herbicide savings and optimize application timing.

Herbicide Management: Session 1

249 - Endangered Species Act: Evolution from Draft Herbicide Strategy to Today

Bill Chism[1]

[1]WSSA

The Endangered Species Act became law in 1973 but has only recently led to changes in pesticide labels. The presentation will discuss how we got to this point, the repeated improvements to the overall system, and examples of ESA labeling mitigations.

250 - Empera ViragessTM Herbicide, a New Rapidicil Containing Premixture for Burndown and Residual Weed Control.

Sam Noe[1], Pat Clay[1], Eric Ott[1], Garrison Gundy[1], Chad Smith[1], Nathan Drewitz[1], Matt Griffin[1], Ron Estes[1], Greg Clarke[1]

[1]Valent USA

Empera Viragess™ is a new Rapidicil® (epyrifenacil) containing herbicide premixture with flumioxazin and pyroxasulfone that combines powerful burndown activity with long-lasting residual weed control. Empera Viragess™ has recently received EPA registration and will be available for use in soybean as a preplant burndown or for use in fallow applications. Empera Viragess™ at 200 g ai ha^{-1} has shown strong broad spectrum burndown activity when mixed with glyphosate and 2,4-D on a variety of spring weeds while providing lasting control of summer annual weeds. In 2025 and 2026, several small-plot research trials were conducted across the US to evaluate Empera Viragess™ against commercial standard products in a soybean preplant burndown system. Empera Viragess™ has been tested with several post-emergence tank-mix partners including dicamba, glufosinate, glyphosate and 2,4-D and demonstrated tank-mix flexibility and effective weed control. Empera Viragess™ tank-mixed with glyphosate and 2,4-D proved to be an effective and competitive program when compared with other commercial standard products.

251 - Convintro™ Herbicide: A New Tool for Managing Amaranthus Species in Corn and Soybean

Katilyn Price[1], Paramita Deria[1], Carl Coburn[1], Emily Scholting[1]

[1]Bayer Crop Science

The continued development and spread of herbicide resistance constitutes a major threat to corn and soybean producers across the United States. Some *Amaranthus* species, such as waterhemp and Palmer amaranth, have developed resistance to multiple herbicide modes- and sites- of action and are among the most challenging broadleaf weeds to control. Convintro™ is a herbicide that contains the active ingredient diflufenican, a Group 12 phytoene desaturase (PDS) inhibitor site of action. Given the increasing challenge of managing herbicide-resistant weeds, diflufenican is being evaluated in field trials in North America for residual activity on *Amaranthus* spp. Bayer field trials were conducted in 2026 to evaluate weed control efficacy and foliar response of Convintro herbicide in soybeans and corn. Convintro™ will provide growers in 2027 a new weed management tool for their integrated weed management practices.

252 - Vyconic™ Soybeans: A Flexible Approach to Future Weed Management

Katilyn Price[1], Carl Coburn[1], Emily Scholting[1]

[1]Bayer Crop Science

Vyconic™ soybean will offer the industry's first trait stack with tolerance to five herbicides (glyphosate, glufosinate, dicamba, 2,4-D and mesotrione-based herbicides) to enable the broadest suite of weed management options, pending applicable regulatory approvals. Bayer Crop Science is developing Versile™ herbicide, a microencapsulated acetochlor plus mesotrione premix, and Tronulva™ herbicide, a propriety 2,4-D formulation, for use in Vyconic™ soybean. This session will provide a preliminary update on product development, weed control efficacy and crop response data from field trials. Given the increasing challenge of managing herbicide-resistant weeds, Vyconic™ soybean will provide growers with added flexibility in their herbicide programs.

253 - Evaluation of VersileTM Herbicide in Field Corn in the Upper Midwest

Sarah Striegel-Engen[1], Katilyn Price[1], Emily Scholting[1]

[1]Bayer Crop Science

Bayer Crop Science is developing Versile™ Herbicide, a formulation containing microencapsulated acetochlor and mesotrione. Though not the primary expected use pattern for the product, Versile™ Herbicide is approved for applications in field corn. Microencapsulated acetochlor products generally

have a more flexible postemergence application window in field corn than other acetochlor formulations. Commercially available microencapsulated acetochlor products are typically labeled for preemergence applications in field corn, but there are notable geographical restrictions in place limiting these applications for microencapsulated acetochlor products that do not contain a safener. Field trials were conducted in the upper Midwest in 2024-2026 to evaluate crop safety and performance of Versile™ Herbicide in field corn. Enabling preemergence use of Versile™ Herbicide in a broader geography in field corn would improve flexibility and would be a valuable weed management tool for growers.

254 - Empera® and Empera Viragess™ - Weed Control and Stewardship for Herbicide Formulations Containing Rapidicil®

Pat Clay[1], Matt Griffin[1], Sam Noe[1], Eric Ott[1], Garrison Gundy[1], Chad Smith[1], Nathan Drewitz[1], Ron Estes[1], Greg Clarke[1]

[1]Valent U.S.A. LLC

Rapidicil® (epyrifenacil) is a novel protoporphyrinogen oxidase (PPO)-inhibiting herbicide active ingredient that provides rapid postemergence activity against labeled broadleaf and grass weeds. *Rapidicil* also demonstrates translocation through both xylem and phloem and is effective at a low application rate of 20 g ai ha^{-1}. In 2026, the United States Environmental Protection Agency (EPA) approved registrations for *Empera* and *Empera Viragess* Herbicides.

Empera Herbicide is a single active ingredient herbicide containing *Rapidicil*. The label includes uses for preplant and preemergence applications to soybean, preplant to wheat, controlling a failed stand of corn, and postharvest/fallow uses on land associated with corn, soybean and wheat production.

Empera Viragess Herbicide is a three-way premix containing *Rapidicil*, flumioxazin and pyroxasulfone providing burndown and residual control of labeled weeds. *Empera Viragess* is labeled for preplant and preemergence applications in soybean, preplant applications to spring wheat at least 30 days prior to planting, and postharvest/fallow applications on land associated with corn, soybean and wheat production.

To support product stewardship and resistance management, both herbicides require a tank-mix with at least one additional effective site of action herbicide for postemergence weed control. Other stewardship requirements include daily sprayer cleaning with Valent Tank Cleaner MaxEvac™ and adherence to specific droplet sizes and spray drift buffers for ground and aerial application. When applied according to label use instructions, no runoff mitigation points are required if application does not occur in a pesticide use limitation area (PULA). Applicators must consult the EPA website Bulletins Live! Two to determine if application will occur within PULA and comply with all additional restrictions listed.

255 - Novel Fenclorim Seed Treatment Provides Enhanced Safety of Wheat to Pre-emergence Applications of Pyroxasulfone

Ryan Bryant-Schlobohm[1], Nanda Kumar[1], Jason Norsworthy[2], Ryan Henry[1], Cody Gray[1]

[1]UPL, [2]University of Arkansas

Pyroxasulfone is an important tool for many weed management programs. Increasing levels of ALS and ACCase resistance in multiple grassy weed species have necessitated the increased use of herbicides like pyroxasulfone in wheat. Delayed pre-emergence applications of pyroxasulfone are generally safe to wheat. However, as many grassy weed species can germinate in tandem with wheat, the delayed pre-emergence timing produces challenges as it relates to optimum timing for efficacious weed control from a pre-emergence herbicide. Pyroxasulfone is labeled for preplant and pre-emergence application timings in wheat, but consistency of crop safety is reduced at these timings. Fenclorim is a novel herbicide safener seed treatment that has demonstrated an ability to safen wheat to preplant and pre-emergence applications of pyroxasulfone. The use of fenclorim enables wheat growers to reduce the risk of crop injury from preplant and pre-emergence applications of pyroxasulfone, further optimizing the ability to apply a highly effective herbicide across an optimized application window.

257 - Characterizing the Response of Multiple Illinois Waterhemp (*Amaranthus tuberculatus*) Populations to S-metolachlor, mesotrione, and 2,4-D

Logan Miller[1], Aaron Hager[1]

[1]University of Illinois at Urbana Champaign

Group 15 resistance has been confirmed in two waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] populations in Illinois. A commonality of these two populations was the additional occurrence of reduced sensitivity to Group 4 and 27 herbicides. Further research confirmed both of these populations demonstrated resistance to Group 4 and 27 herbicides. Given the widespread usage of Group 15 herbicides, mesotrione, and 2,4-D in corn and soybean, the objective of this study was to characterize the response of several Illinois waterhemp populations to S-metolachlor, mesotrione, and 2,4-D. During the fall of 2023, female waterhemp inflorescences were collected from 127 randomly selected soybean fields across Illinois, along with samples submitted by individuals who suspected their populations exhibited resistance to Group 15 herbicides. Following screening of all populations with a discriminating dose of S-metolachlor, 29 populations were selected representing sensitive, low-level resistant, and high-level resistant responses for further evaluation with mesotrione and 2,4-D. Populations were screened in the greenhouse by conducting whole-plant dose-response assays twice with five replications each run in a completely randomized design with nine rates of mesotrione (0-15,800 g ai ha^{-1}; mesotrione) plus ammonium sulfate (2.5% v/v) and crop oil concentrate (1% v/v); and ten rates of 2,4-D (0-17,920 g ae ha; 2,4-D choline) plus ammonium sulfate (2.5% v/v). Plants (10-12 cm) were sprayed in a chamber equipped with an 80015 EVS nozzle delivering 187 ha^{-1} at 207 kPa. Visual assessment of plant injury was recorded at 7, 14, and 21 days after treatment (DAT), along with mortality and dry biomass at 21 DAT.

258 - Weed Management with Perennial Groundcover in Corn

Erin Haramoto[1], Hallie Sandeen[1], Kiera Searcy[1]

[1]University of Kentucky

Perennial groundcovers (PGC), or perennial cover crops or living mulches, can reduce soil erosion and nutrient loss and, if properly managed, maintain crop yield. The PGC may suppress weeds in the main cash crop; PGC biomass, its ground coverage, and the weed community in the field will impact suppression. However, all herbicides must be compatible with the PGC, so chemical management options may be limited. We conducted field experiments outside Lexington, KY, in 2024 and 2025 to determine weed suppressive potential of a Kentucky bluegrass (*Poa pratensis* L.) PGC and test corn (*Zea mays* L.) pre-emergence herbicide compatibility. We suppressed the fall-planted PGC the following spring with glufosinate to stop active growth without killing the plants, then strip-tilled and planted corn into the strips. Our experiment had pre-emergence herbicide treatments as the main plot factor and a post-emergence herbicide as the sub-plot factor. Immediately following corn planting, we applied four pre-emergence herbicide treatments (mesotrione, clopyralid, and pyroxasulfone as single active ingredient products, and a pre-mix with all three active ingredients) along with two control treatments, PGC and no PGC plots without pre-emergence herbicides. We applied a post-emergence herbicide (mesotrione + bicyclopyrone + pyroxasulfone + *s*-metolachlor) to one subplot in each main plot at corn V5; the other subplot did not receive the POST herbicide. Weed density was determined to the species level prior to the POST and again prior to harvest, and weed biomass was also collected at harvest in 2024. The PGC without pre-emergence herbicide did not reduce weed density relative to no PGC and no pre-emergence herbicide at POST or at harvest in either year of the experiment, suggesting our stand of PGC was not contributing additional weed suppression for species present in the experiments. In 2024, mesotrione, pyroxasulfone, and the pre-mix combination reduced V5 and harvest weed density, as well as harvest weed biomass relative to clopyralid alone and the two treatments without PRE. The POST also reduced weed density and biomass at harvest in this year. No differences in weed density were observed in 2025 and weed biomass at harvest was minimal and not collected. The PGC biomass at harvest was not affected by the PRE herbicides in 2024 and was greater where POST was applied; biomass averaged approximately 100 g m-2 by harvest. Grass survival was minimal in 2025 and it was not sampled. Additional experiments show that the PGC was not affected by other pre-emergence herbicide active ingredients including atrazine, isoxaflutole, dimethenamid-p, thiencarbazone-methyl, and saflufenacil, broadening the number of pre-emergence products that can be applied to corn. Additionally, PGC can survive at least one early-season glyphosate application, offering an alternative broad-spectrum systemic product. Broadly, our research shows that effective pre-emergence herbicides that suppress the weed community present in the field are necessary to manage weeds in PGC stands with low to moderate biomass levels. Producers with more PGC biomass and/or established stands may not need these applications and future research should confirm this potential.

259 - Influence of tank-mix partners on Empera® Herbicide for cover crop termination

Eric Ott[1], Ron Estes[1], Sam Noe[1], Chad Smith[1], Garrison Gundy[1], Gregory Clarke[1], Nathan Drewitz[1], Pat Clay[1]

[1]Valent USA LLC

Empera® Herbicide (epyrifenacil) is a new, fast acting PPO inhibiting herbicide, that translocates in the xylem and phloem, has postemergence herbicidal activity on broadleaves and grasses, and has recently received EPA registration. When applied to cereal rye cover crops, Empera 20 g ai ha^{-1} tank-mixed with glyphosate has been shown to increase speed of termination activity compared to glyphosate alone. This past year, several small plot research trials were initiated to investigate non-glyphosate tank-mix partners in combination with Empera for spring cover crop termination.Tested tank-mix herbicides included; clethodim, quizalofop-p-ethyl (139 g ai ha-^{1}), fluazifop-p-butyl (420 g ai ha^{-1}), and glufosinate (880 g ai ha^{-1}). Trials also investigated Empera tank-mixes with known antagonists, glyphosate + atrazine (560 g ai ha^{-1}), as well as glyphosate with UAN fertilizer as a carrier. The addition of Empera Herbicide can significantly increase speed of cereal rye cover crop termination when tank-mixed with several herbicides. Empera can also help overcome known herbicidal antagonisms to achieve quicker, and more thorough spring cereal termination.

260 - Cover Crop Effects on Waterhemp (*Amaranthus tuberculatus*) Population Structure Influence Glufosinate Efficacy

Laurel Wellman[1], John Wallace[1]

[1]Penn State

Cover crops are recognized as important weed management tools, but their interaction with subsequent weed management tactics is less understood. In a multi-stressor framework, cover crops act as ecological stressors that can alter expression of individual traits within the population, which may change the efficacy of subsequent stressors. In a 2-yr field experiment, we manipulated cover crop stressor intensity and duration (no cover crop control, plus harvested or roll-crimped cereal rye (*Secale cereale* L.)) and waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] seedbank density (50, 500, 5000, 50000 seeds 0.5 m^{-2}). We evaluated the effects of the emergent waterhemp demographics on survivorship to glufosinate among cover crop stressor effects. Glufosinate efficacy depended on waterhemp density: waterhemp survivorship to glufosinate increased from 28% at low waterhemp density (< 15 plants 0.25 m^{-2}) to 68% at high density (1200 plants 0.25 m^{-2}). Waterhemp survivorship to glufosinate was positively correlated with the number of individuals > 10 cm. The roll-crimped cereal rye treatment decreased waterhemp survivorship to glufosinate, which may have been driven by greater waterhemp specific height (cm g^{-1}). Our results indicate that glufosinate was more effective at low waterhemp densities and when individuals were small. Furthermore, survivorship of waterhemp exposed to stress from the roll-crimped treatments was lowest, suggesting that roll-crimped cereal rye and postemergence herbicides are synergistic multi-stressor tactics for waterhemp management and may serve as a proactive herbicide resistance management tool. To our knowledge, this is one of the first reports that glufosinate efficacy differs as a function of previous cover crop stressors.

261 - Integrated Weed Management in Truvera Sugarbeet: A Comparison of Tillage Systems

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[1]Michigan State University

Strip tillage is gaining popularity in row crop production because it reduces soil compaction and erosion while conserving water and maintaining some seedbed preparation benefits of conventional tillage. However, adoption in sugarbeet production has been limited by a lack of effective in-crop weed control options. The introduction of Truvera sugarbeets, which allow in-crop applications of glyphosate, glufosinate, and dicamba, may provide additional opportunities for weed management in reduced tillage systems. Therefore, research was conducted in 2025 and 2026 in East Lansing (EL) and Frankenmuth (SVREC), Michigan, to determine the influence of tillage system and herbicide program on weed control in Truvera sugarbeet. The field experiment was arranged as a split-split-plot randomized complete block design with four replications. The main plot factor was tillage system, which had two levels: conventional or strip tillage. The sub-plot factor consisted of with and without dicamba PRE. The sub-sub-plot factor consisted of 8 different postemergence (POST) herbicide programs, including a nontreated control. POST herbicide programs consisted of herbicide applications at 2 leaf (lf), 6-8 lf, and 12 lf sugarbeet. The 2 and 6-8 lf applications included various combinations of glyphosate, glufosinate, dicamba, and acetochlor, while 12 lf applications consisted of glyphosate alone. At the 12 lf application timing, there was a significant tillage × PRE × POST interaction for common lambsquarters (*Chenopodium album* L.) control at SVREC 2025. In conventional tillage, dicamba PRE followed by two POST glufosinate applications provided 95% control, compared with 65% without dicamba PRE. All other POST treatments resulted in 99% common lambsquarters control. At the remaining three site-years, a significant PRE × POST interaction indicated no difference in control between POST herbicide programs with or without dicamba PRE. Including glufosinate in the POST program improved horseweed control at the 12 lf evaluation from 74 to 99% compared with three POST applications of glyphosate, averaged over PRE and tillage system. In EL 2025, dandelion (*Taraxacum officinale*) control at 12 lf evaluation was influenced by a tillage × POST interaction. Conventional tillage provided 99% control across POST programs, while only acetochlor + glufosinate + glyphosate fb. glufosinate + glyphosate resulted in lower control (89%) under strip tillage. No sugarbeet injury was observed with any of the herbicide treatments. However, sugarbeet stand was up to 41% lower when no POST herbicide application was made, due to weed competition with the sugarbeet. In EL in 2026, sugarbeet stand was 9% lower when no PRE was applied. Consequently, there was a 14% decrease in yield in EL 2026 when there was not a PRE. Tillage influenced yield in 2 of 4 site-years, with strip tillage increasing yield by 15% at SVREC 2025, but decreasing yield by 29% at EL 2026 compared with conventional tillage. These findings indicate Truvera sugarbeets provide an opportunity to integrate strip tillage into sugarbeet production systems while maintaining effective weed control, including control of difficult-to-manage weeds such as glyphosate-resistant horseweed. However, yield responses to tillage varied across site-years, indicating that strip tillage did not consistently provide comparable yield to conventional tillage.

Weed Biology and Ecology

262 - Residual Herbicide Activity in Cover Crop Residue: Sprayed Versus Dry Fertilizer Impregnation

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Cover crop residues can intercept and retain 50% or more of residual herbicides when applied as a broadcast spray, potentially reducing effectiveness. The objective of this research was to determine if fertilizer impregnation increases herbicide performance compared to broadcast spray application in a rolled cover crop. In a cereal rye followed by soybean system, research evaluated fomesafen at 0.27 kg ai/ha, *S*-metolachlor at 1.18 kg ai/ha, and a combination thereof at sites in Virginia, Maryland, Pennsylvania, and Delaware. In a hairy vetch followed by corn system, research evaluated atrazine at 1.83 kg ai/ha, *S*-metolachlor at 1.21 kg ai/ha, and a combination thereof at one site in Virginia. All plots were terminated the day of crop planting with non-residual herbicides. Treatments were applied as a broadcast spray at 140 L/ha or on fertilizer carrier to compare application methods. All plots received the same fertilizer amount including a nontreated check. Palmer amaranth was present in Virginia and Delaware sites while waterhemp was present in Pennsylvania. Maryland did not have significant weed pressure and was thus not included in the analysis. In soybean, cereal rye ranged 1900 to 4700 kg/ha at treatment application. Spreading herbicides on fertilizer resulted in greater *Amaranthus* spp. control than when sprayed: 81 versus 71% control and 80 versus 112 weeds/m^2, 4 weeks after application. However, differences were not detected between spraying versus spreading for large crabgrass control or density. Differences among herbicides were also detected. No differences were detected in soybean yield, which averaged 4,500 kg/ha (data limited to 3 sites). Similar results were obtained in the corn following hairy vetch system. Hairy vetch biomass was 2100 kg/ha at treatment application. Palmer amaranth control was better when herbicides were spread compared to sprayed, 70 versus 57%. However, no differences in spray versus spreading methods were observed for Palmer amaranth or giant foxtail density or giant foxtail control. Differences among herbicides were also detected. No differences were detected in corn yield, which averaged 7,080 kg/ha. Overall, these data indicate that herbicide spread on dry fertilizer results in similar or better residual weed control than when sprayed. Future research should evaluate higher biomass cover crops, residue management approaches, and other herbicides.

263 - Group 1 Herbicides Have Shown Little Utility to Manage Established Reed Canarygrass (*Phalaris arundinacea*)

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Reed canarygrass (*Phalaris arundinacea* L.) is a circumboreal, rhizomatous, cool-season grass with native and exotic genotypes in North America. It is a challenging weed in riparian

reforestation/afforestation efforts in the Chesapeake Bay watershed. In restoration regimens proposing native herbaceous communities, selective herbicides are desired. This element of our ongoing restoration evaluations investigated the utility of the Group 1 herbicides clethodim (0.28 kg/ha), fluazifop-P (0.42 kg/ha), quizalofop-P (0.12 kg/ha), and sethoxydim (0.53 kg/ha) to suppress established reed canarygrass compared to glyphosate (3.4 kg/ha). Trials were established May 7, May 19, June 5, and October 2, 2025 in a small-stream floodplain in Pennsylvania Furnace, PA, to approximate early-vegetative, late-vegetative, flowering, and post-flowering phenologies. All response evaluations were visual, and the evaluation schedules were not consistent across trials. Glyphosate was completely effective and distinct from the untreated and Group 1 plots at all ratings. The early-vegetative, late-vegetative, and flowering timing trials were rated September 2, 2025, and the Group 1 plots were simply rated as “different from check?” and were not. The post-flowering plots were rated April 29, 2026, and the Group 1 plots were again indistinguishable from the untreated plots.

264 - Evaluating Soil Carbon and Nitrogen Stocks Following Invasive Woody Plant Control in Forests

Stefania Cartoni-Casamitjana[1], Mark Renz[1]

[1]University of Wisconsin-Madison

Invasive plants are overwhelming midwestern forests, eroding the diversity and benefits society receives from healthy forests. Common invasive woody invasive plants to midwest forests include common buckthorn (*Rhamnus cathartica*) and bush honeysuckle (*Lonicera* spp.). Research has demonstrated impacts to plant diversity which degrades the value of the habitat for mammals, birds, and pollinators. Of additional concern is the alteration of soil processes which increase belowground soil carbon and nitrogen in the soil. While management methods are known and effective, information about how these treatments influence below ground carbon and nitrogen is not known. Additionally, concern exists that management techniques increase compaction of forest floors. We will present results from an experiment evaluating woody plant control with a combination of goat browsing, forestry mowing, and herbicides compared to a non-treated control. Soil measurements (% C, % N, soil bulk density) were taken in the top 60 cm and used to calculate carbon and nitrogen stocks. Additionally carbon and nitrogen were separated into fractions that breakdown quickly (POM) and slowly (MAOM) in the top 20 cm. These responses were compared among treatments two years after management ended. Bulk density was increased in several treatments but increases were not high enough to impact plant growth. While carbon stocks (kg ha^{-1}) were found similar among treatments, effective invasive plant management approaches reduced N stocks by 21 - 37%, but only at the 20-40 cm depth. No differences in POM or MAOM were observed among treatment. Further analysis of C and N stocks compared to woody plant cover across treatment suggest that reductions in cover can reduce C and N stocks that breakdown quickly (POM). However any potential reductions are small (<3%) compared to the total C and N stocks. These findings suggest belowground carbon and nitrogen stocks can be reduced with removal of woody invasives but the process will likely require longer periods than four years to be impactful.

265 - Light Up the Weed Seedbank: A Management Approach Using Photocontrol During Tillage

Sarah Kezar[1], Rodrigo Werle[1]

[1]University of Wisconsin-Madison

During spring tillage events, a low fluence response (sensitivity to Pfr) helps seeds terminate dormancy even under a millisecond of exposure to red light from the sunlight. Small-seeded weeds brought to the soil surface by tillage have the greatest potential for seedbank exhaustion because exposure to light and shallow burial oftentimes creates high flushes of germination. Seminal tillage studies have connected the ecological response of germination during daytime tillage due to a light flash experienced by the seeds or a suppression of germination with nighttime tillage. Thus, tillage is regarded as a management strategy that can continue to be optimized for manipulating seed germination and emergence. The purpose of this research was to evaluate the effect of light-emitting diode (LED) lights in the form of red or far-red light that are applied during spring tillage on weed emergence dynamics and their interaction with the crop production system (corn, soybean). A field trial was conducted at the Lancaster Research Station in Lancaster, WI in 2025 and 2026 across a conventional corn and soybean field to evaluate weed suppression and emergence dynamics in response to light exposure treatments during spring tillage. The experiment was a factorial split-split-split plot design, with each treatment level replicated four times in the form of four cultivation passes. The first factor compared the weed emergence response, at the species level, to cultivation with two light exposure treatments, R- or FR-light, to ambient light conditions as the non-treated control (NTC). The second factor was the four times of day (time) of cultivation at 0900, 1200, 1700, and 2100. The third factor was the two conventional cropping systems, corn or soybean. Weed emergence counts were collected in 4 random quadrats (0.5 m^2) per subplot at 2, 4, 6, 8, and 10 weeks after tillage (WAT). This original research seeks to contribute to the establishment of a novel, non-chemical seedbank management tactic through LED light exposure in the form of red and far-red light to affect weed emergence dynamics.

Graduate Student Symposium – 30 Years of Weed Science

266 - 30 Years of Weed Science: What Changed, What Worked, and What Comes Next

Abigail N. Norsworthy[1], Laurell Wellman[2], Jacob H. Felsman[3], Jackson Alsdorf[4]

[1]Purdue University, [2]Penn State University, [3]Michigan State University, [4]North Carolina State University

Over the past 30 years, weed science has undergone substantial transformations driven by advances in herbicide chemistry, shifts in regulatory frameworks, the rapid evolution of herbicide-resistant weed populations, and increasing societal expectations on weed management practices. These converging pressures have not only changed the tools available but have fundamentally reshaped how weed scientists

define problems, evaluate risk, and develop management strategies. Understanding this trajectory is critical. The Graduate Student Organization (GSO) has organized a symposium that aims to bridge historical perspectives with forward-looking innovation, enabling students to understand what has changed and why it matters. The first hour will focus on changes over the past 30 years of weed science, with topics spanning herbicide formulations (Cara McCauley, Corteva), extension weed science (Aaron Hager, Univ. of Illinois Urbana-Champaign), weed management recommendations in light of changing weather conditions (Erin Burns, Michigan State), and improvements to adjuvants (Jim Reiss, Chemorse). Following a break, the second hour will focus on the future of weed science. Presentations will include the role of automation in specialty crops and academia (Lynn Sosnoskie, Cornell AgriTech), AI-enabled herbicide applications in vegetable crops (Thierry Besançon, Rutgers), predicting herbicide resistance (Eric Patterson, Michigan State), and adopting integrated weed management at scale (Rodrigo Werle, UW-Madison). By integrating academic, extension, and industry viewpoints, this symposium will equip students with the context needed to continue contributing to the future of weed science.

267 - Are Traditional Weed Management Recommendations Still Relevant Under Today's Weather Conditions?

Erin Burns[1]

[1]Michigan State University

Abstract not available.

268 - Weed Management and Climate Change

Caroline Marschner[1], Sharon Bachman[1], Isabella Colucci[1], Sophie Westbrook[2], Antonio DiTommaso[1]

[1]Cornell University, [2]Kansas State University

Weeds and climate change: competitiveness, herbicide efficacy, range shifting, etc.

269 - One Plant at a Time: Ai-Enabled Herbicide Applications in Vegetable Specialty Crops

Thierry Besancon[1], Luke Mackara[1], Lynn Sosnoskie[2]

[1]Rutgers University, [2]Cornell AgriTech

Abstract not available.

270 - Integrated Weed Management Reimagined: Beyond Innovation, Toward Adoption at Scale

Rodrigo Werle[1]

[1]University of Wisconsin-Madison

Abstract not available.

271 - Can We Predict Resistance Before It Happens?

Eric Patterson[1]

[1]Michigan State University

Abstract not available.

272 - To What Extent Have Herbicide Formulations Improved Over 30 Years?

Cara McCauley[1]

[1]Corteva Agriscience

Abstract not available.

273 - Changes in Weed Science From An Extension Lens Over A 30 Year Career.

Aaron Hager[1]

[1]University of Illinois

Abstract not available.

274 - Have There Been Substantial Improvements In Adjuvants Over The Last 30 Years?

Jim Reiss[1]

[1]Chemorse

Abstract not available.

275 - The Role of Automation in Specialty Crops and Academia

Lynn M. Sosnoskie[1]

[1]Cornell University

Abstract not available.

Herbicide Management: Session 2

276 - Comparison of Pre-Mix and Tank-Mix Components Containing Epyrifenacil on Droplet Characteristics, Deposition, and Weed Control

Milos Zaric[1], Garrison Gundy[2], Pat Clay[2], Nicholas Fleitz[3], Vojin Milosevic[1], Breno Rodrigues[1], Renata Naves[1], Shrijana Poudel[1], Kasey Schroeder[1], Jeffrey A. Golus[1]

[1]University of Nebraska-Lincoln, [2]Valent U.S.A LLC, [3]Pentair-Hypro

Commercial herbicide pre-mixes offer application convenience, whereas tank mixing individual products provides flexibility in product selection and formulation. However, formulation differences may affect spray characteristics and weed control even when active ingredient rates are equivalent. This study compared a commercial pre-mix containing flumioxazin (88.3 g ai ha^{-1}), pyroxasulfone (90.4 g ai ha^{-1}), and epyrifenacil (21.0 g ai ha^{-1}) with a tank mix of the same active ingredients at equivalent rates. Objectives were to evaluate spray droplet size, coverage, and postemergence herbicide efficacy. Treatments included the commercial pre-mix, individual active ingredient formulations, all two-way combinations, and the three-way tank mix. Water served as the spray characterization baseline. Spray solutions were delivered through a PSLDMQ2004 nozzle at 276 kPa and 140 L ha^{-1}. Median droplet diameter (DV0.5) and the percentage of spray volume contained in droplets smaller than 141 µm were determined, while spray coverage was quantified using kromekote cards as collectors. Greenhouse efficacy was evaluated against Palmer amaranth (*Amaranthus palmeri* S. Watson), velvetleaf (*Abutilon theophrasti* Medik.), common lambsquarters (*Chenopodium album* L.), green foxtail [*Setaria viridis* (L.) P. Beauv.], and kochia [*Bassia scoparia* (L.) A. J. Scott] on plants 8 to 14 cm in height. Visual control and dry weight reduction were assessed, with results presented at 6 days after application. The three-way tank mix increased spray coverage relative to the pre-mix (47.4% versus 42.8%), although median droplet diameters were similar (453 versus 443 µm). Both formulations produced low percentages of spray volume contained in droplets smaller than 141 µm (1.97% and 2.08%, respectively), compared with 3.40% for water. Visual control with the pre-mix and tank mix was comparable for Palmer amaranth (100% for both), velvetleaf (100% for both), common lambsquarters (about 98.5% for both), kochia (100% for both), and green foxtail (95% versus 83%). Dry weight reduction ranged from 53% to 85% for the pre-mix and 63% to 80% for the tank mix across species, with no difference in responses between formulations. These findings indicate that equivalent active ingredient loads may deliver similar early

weed control through either a commercial pre-mix or individually assembled tank mix, despite measurable differences in spray coverage. Product selection may therefore consider cost, handling convenience, inventory requirements, mixing flexibility, and operational preferences. Further field research is needed to determine whether these formulation differences influence soil residual activity and weed control under field conditions.

277 - Changing the Message: An Analysis of 75 Years of Corn and Soybean Herbicide Advertising

Kevin Bradley[1]

[1]University of Missouri

Herbicide advertisements provide a unique perspective on the history of weed management and how the products, weeds, and marketing messages used to promote herbicides have changed over time. To characterize changes in corn and soybean herbicide advertising from 1945 to 2020, a total of 2,722 unique herbicide advertisements appearing in the Midwest or Central editions of *Successful Farming* and *Farm Journal* magazines were evaluated. Each advertisement was coded for a variety of characteristics including primary and secondary persuasive appeals, primary and secondary visual elements, and additional persuasive content such as testimonials, humor, and negative comments about competing products. Persuasive appeals were classified into 10 categories, including efficacy/control, economics/productivity, fear/loss avoidance, authority/science, progress/modernity, convenience, stewardship/responsibility, incentives, association/peer pressure, and inspirational/patriotic themes. Advertisements were also evaluated for the presence of educational information pertaining to herbicide mechanisms of action and herbicide resistance, as well as explicit yield or weed control data. Changes in these characteristics were examined over time to identify trends in herbicide advertising and the messages communicated to corn and soybean producers. Regardless of time period, efficacy and convenience were consistently among the most common persuasive appeals, while the frequency of other appeals, such as economics/productivity and association/peer pressure, varied over time. The percentage of advertisements mentioning herbicide resistance increased from 2.3% in the late 1980s to 32% in 2015-2020, while the percentage of advertisements containing educational information pertaining to the active ingredient or herbicide mechanism of action has actually declined from the earliest years of herbicide discovery. These findings provide a unique historical perspective on changes in herbicide advertising and how the messages used to promote weed control have evolved alongside the challenges faced by corn and soybean producers.

278 - Revisiting the Use of Group 15 Herbicides for Waterhemp (*Amaranthus tuberculatus*) Control in Soybean

Rodrigo Werle[1], Guilherme Chudzik[1], Ryan DeWerff[1], Christy Sprague[2], Sarah Ganske[3], Debalin Sarangi[4], Ryan Miller[4], Kevin Bradley[5], Joseph Ikley[6], Alyssa Essman[7], Colin Barclay[7], Amit Jhala[8], Eric Jones[9], Wesley Everman[10]

[1]University of Wisconsin-Madison, [2]Michigan State University, [3]Kansas State University, [4]University of Minnesota, [5]University of Missouri, [6]North Dakota State University, [7]Ohio State University, [8]University of Nebraska-Lincoln, [9]South Dakota State University, [10]Iowa State University

Waterhemp [*Amaranthus tuberculatus* (Moq.) J.D. Sauer] is one of the most challenging weeds in Midwestern U.S. soybean production due to its extended emergence period, rapid growth, and widespread resistance to multiple herbicide sites of action. Layered residual herbicide programs, consisting of a preemergence (PRE) application followed by an additional residual herbicide applied postemergence (POST), are widely recommended to improve season-long waterhemp control. Group 15 herbicides are central to this strategy because they can be applied both PRE and POST. However, splitting Group 15 herbicide rates between applications may compromise early-season residual control and increase reliance on POST herbicides. Effective layering also requires timely POST applications, which can be challenging under current regional management practices. Growers and commercial applicators often delay POST applications until weeds begin escaping PRE residual control and soybean approaches herbicide application cutoff stages or canopy closure, aiming to maximize foliar herbicide effectiveness and minimize additional applications. Such delays may reduce the residual benefits of layering. The recent confirmation of Group 15-resistant waterhemp populations further underscores the importance of optimizing herbicide use. Field experiments were conducted across 10 U.S. states (IA, KS, MI, MN, MO, ND, NE, OH, SD, and WI) during 2025 and 2026 to evaluate Group 15 herbicide rate and application timing for waterhemp control in soybean. Treatments included *S*-metolachlor (full rate = 2,141 g ai ha^{-1}) and pyroxasulfone (full rate = 128 g ai ha^{-1}), each applied at a full rate PRE, full rate POST, half rate PRE followed by half rate POST, half rate PRE only, or half rate POST only. All treatments received a common PRE foundation of sulfentrazone (218 g ai ha^{-1}) plus cloransulam-methyl (27 g ai ha^{-1}) and a common POST application of 2,4-D choline (1,065 g ae ha^{-1}), glufosinate-P (339 g ae ha^{-1}), and glyphosate (841 g ae ha^{-1}). Waterhemp control was visually assessed at POST application and near soybean harvest to evaluate early-season residual activity and season-long control, respectively. Preliminary results indicate that applying a full rate of either Group 15 herbicide PRE, in combination with sulfentrazone plus cloransulam-methyl, provided greater waterhemp control at POST compared with reduced PRE rates or delaying Group 15 applications until POST. However, end-of-season control was generally comparable among programs receiving a full cumulative Group 15 rate, whether applied entirely PRE, entirely POST, or split equally between applications. *S*-metolachlor and pyroxasulfone performed similarly at the full rates evaluated. These findings highlight the importance of prioritizing robust PRE programs rather than compromising early-season residual control to accommodate potentially delayed layered applications. Maximizing waterhemp suppression before POST may reduce reliance on foliar herbicides and associated resistance selection pressure. Optimizing Group 15 herbicide rates and timing is critical for sustaining their effectiveness across soybean and other cropping systems.

279 - Characterizing herbicide-resistant waterhemp in Iowa

Wesley Everman[1], Iththiphonh Macvilay[1], Tunde Akanbi[1], Carol Wayhs Backes[1], Rocco D'Antico[1]

[1]Iowa State University

Herbicide-resistant waterhemp has been tracked historically in Iowa through a weighted survey of plants remaining just prior to harvest in areas of greatest corn and soybean production. Surveys were conducted in 2013, 2019, and 2025 by travelling to predetermined points, searching for waterhemp within the field, and collecting seedheads throughout the field. These samples were dried, threshed, and seed stored in cold storage until greenhouse screens were conducted. Waterhemp from each population were sown in flats and transplanted at the 2-leaf stage into conetainers. Once plants reached 4 inches in height, they were treated with discriminating doses of imazethapyr, atrazine, glyphosate, mesotrione, lactofen, dicamba, 2,4-D, and glufosinate. Plants were evaluated for injury and control at 7, 14, 21 days for all herbicides and at 28 days for dicamba and 2,4-D. Plants were evaluated for survival and mortality, and populations with greater than 50% of treated plants surviving an application were deemed resistant. While results for the 2025 survey are not fully complete, trends show an increase in resistance to all herbicides, excluding lactofen. Resistance to imazethapyr, atrazine, and glyphosate is greater than 80%, remaining high compared to previous surveys. Lactofen remains below 15%, while mesotrione resistant populations increase above 40% from 15% in 2019. Dicamba and 2,4-D increased to approximately 40% of populations treated being resistant to each herbicide independently. More than 15% of populations screened survived glufosinate in the 2025 survey. Populations with survivors to 2,4-D and glufosinate were then subjected to dose response studies compared to susceptible populations to determine if these populations are resistant since resistance has not been previously confirmed. Dose response studies indicated two populations were resistant to 2,4-D and two populations were resistant to glufosinate, supporting the results of the survey using discriminating doses. Results from the survey also identified populations which are resistant to 6 or 7 herbicides tested. This is concerning as this represents a startling loss of postemergence herbicides for waterhemp control in corn and soybean fields.

280 - Weed Management in Short-Stature Corn: A Multi-State Assessment of Best Management Practices

Kyle Elizalde[1], Erin Burns[1]

[1]Michigan State University

Corn (*Zea mays L.*) is one of the most economically important crops grown worldwide. Weed competition can reduce yield by 50%. Short statured corn potentially allows for easier in-season management, enhanced severe weather tolerance, and increased planting populations, which can have positive impacts on weed control. Therefore, the objective of this study was to investigate herbicide application timing, hybrid leaf architecture, and planting population on short vs. tall (traditional) statured corn. This study was conducted at nine site-years in 2024 and 2025 across four states (East Lansing and Morrice MI, IN, OH, and KY), following a randomized complete block design with four replications. Factorial treatment combinations consisted of three corn hybrids (tall, short-upright leaves, and short-planophile leaves), two planting populations (79,000-standard and 99,000-high seeds ha^{-1}), and three herbicide programs (preemergence-PRE, early postemergence-EPOS, and preemergence followed by postemergence-two-pass). Weed control ratings, canopy cover/closure, and yield were measured. All site years were combined for analysis. Data were analyzed using linear mixed-effects models in R, and means were separated using Tukey's HSD. Weed control differed by herbicide timing and rating date ($p<0.001$). The two-pass program consistently improved weed control relative to the single-pass programs. Across hybrids and

populations, weed control was 4 and 6% greater than the EPOS and PRE-only programs 14 days after post (DAP), and 6 and 8% greater at 56 DAP. Corn canopy cover at POST differed by hybrid by population and herbicide timing ($p<0.001$ and 0.017). Across herbicide timings, canopy cover was 1-5% greater in the upright hybrid planted at the high population relative to all other combinations. While the two-pass herbicide program averaged across hybrid by population combinations improved canopy cover, differences were marginal (1%) and therefore have little biological significance. Although hybrid-population combinations influenced canopy cover at 56 DAP ($p < 0.001$), treatment differences were modest (1 to 3%), suggesting little practical impact when averaged across herbicide timings. Although hybrid-population combinations affected time to 50% canopy closure ($p < 0.001$), treatment differences were only 2 d (40-42 d), suggesting minimal agronomic impact when averaged across herbicide timings. Yield differed by hybrid-population combination and herbicide program ($p<0.001$, <0.001). Across herbicide programs, the tall standard outyielded all other treatments by 7 to 19%, while the short stature planted at the high population yield was 10% greater than their standard population counterparts averaged across herbicide timings. Averaged across hybrids and populations, the two-pass program yielded 8-14% more than one pass programs. In conclusion, short stature corn responded similar to traditional stature corn in several weed management aspects. Weed control and canopy development, were in large part, similar over the season indicating that short stature corn weed control and canopy development is similar to traditional statured corn. Traditional tall corn yielded more than short stature however this was most likely due to genetic traits as weed control responses were similar across all hybrids. Therefore, current traditional tall corn weed management recommendations will be applicable to short stature corn.

281 - Evaluation of crop tolerance with diflufenican in dry bean

Isabelle Aicklen[1], Peter Sikkema[1]

[1]University of Guelph

Weed interference can cause significant yield losses in dry bean (*Phaseolus vulgaris* L.) production. Historically, growers have relied on a limited number of herbicide active ingredients to effectively control a spectrum of weed species in dry bean. Diflufenican, a phytoene desaturase (PDS) inhibitor, presents a novel active ingredient for weed control in dry bean production. Tolerance to herbicides can vary among market classes and can influence herbicide selection and rate. The purpose of this study was to evaluate the tolerance of four dry bean market classes to preemergence applications of diflufenican. Field experiments were established in Ridgetown and Exeter, ON in 2024 and 2025. Experiments were established as a split-plot factorial design, the main-plot factor being diflufenican rate (0, 60, 180, and 360 g a.i. ha^{-1}) and the subplot factor being dry bean market class (adzuki, kidney, pinto, and white). Data collection included crop injury (%), crop stand counts (plants m^{-1}), crop height (cm), crop dry weight (g $plant^{-1}$), and crop yield at maturity. There was no significant interaction between diflufenican rate and dry bean market class for crop injury at 1, 4, and 8 weeks after emergence (WAE), stand counts, height, dry weights, or yield. These findings indicate that the effect of herbicide rate was generally consistent across market classes. At 2 WAE, when diflufenican was applied at 60 g a.i. ha^{-1}, injury was less than 5% across all market classes. At this same timepoint, significant injury was observed in adzuki bean (26%) when diflufenican was applied at 180 g a.i. ha^{-1} with injury decreasing across other market classes. A similar trend was observed when diflufenican was applied at 360 g a.i. ha^{-1} with up to 61% injury observed in

adzuki bean. Pinto beans were most tolerant (27%) with observed injury being comparable to kidney bean at this timepoint. Within each market class similar trends were observed across timepoints with pinto bean demonstrating greater tolerance irrespective of diflufenican rate. Overall, this study provides insight into the tolerance of dry bean market classes to diflufenican and can help to support the development of market class-specific recommendations.

Weed Genetics and Herbicide Physiology

282 - Assessing Cross-Resistance to Group 15 Herbicides in Waterhemp (*Amaranthus tuberculatus*) Using an Agar-Based Assay

Luma Lorena Loureiro S. Rodrigues[1], Rodrigo Werle[1]

[1]University of Wisconsin

Resistance to very-long-chain fatty acid (VLCFA) inhibitors has become a growing concern, particularly as these herbicides remain an important tool for waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] management. The first confirmed case of waterhemp resistance to Group 15 herbicides in Wisconsin was reported in 2025. This study assessed cross-resistance to acetochlor (nonencapsulated and encapsulated), dimethenamid-P, and pyroxasulfone in waterhemp accessions confirmed resistant to *S*-metolachlor, using an agar-based assay. Two S-metolachlor-resistant waterhemp accessions (A117 and A133) and one susceptible accession (A106) were evaluated in dose-response experiments with herbicide concentrations equivalent to 0.031× to 8× the labeled field rate (converted to mg ai L^{-1}) for nonencapsulated acetochlor (1,960 g ai ha^{-1}), encapsulated acetochlor (1,261 g ai ha^{-1}), dimethenamid-P (736 g ai ha^{-1}), and pyroxasulfone (110 g ai ha^{-1}); nontreated check was included. Stock solutions of each herbicide were prepared in distilled water at concentrations expressed in mg ai L^{-1}. Agar was prepared at 0.6% (w/v) and cooled to 40 °C. The stock solution was incorporated into the agar medium to achieve the desired herbicide concentration, and the mixture was poured into Petri dishes (9 cm in diameter). Twenty-five seeds were placed on the agar surface. After 21 days, the number of germinated seeds and surviving seedlings were recorded. Survival was corrected using the Abbott's equation to account for natural seedling mortality observed in the nontreated check. Dose-response curves were fitted using the *drc* package in R, with model selection based on AIC. The rates required to reduce survival by 90% (ED_{90}) were estimated from the fitted curves. Resistance index (RI) was calculated by dividing the ED_{90} of each suspected-resistant accession by that of the susceptible accession. For acetochlor (nonencapsulated), the ED_{90} values for A117 (152.9 g ai ha^{-1}) and A133 (159.1 g ai ha^{-1}) exceeded those of A106 (96.8 g ai ha^{-1}; $p<0.0001$), resulting in RI values of 1.6 for both accessions. For encapsulated acetochlor, A117 exhibited the greatest ED_{90} (1433.4 g ai ha^{-1}, RI=6.6), whereas A133 had an ED_{90} of 585.8 g ai ha^{-1} (RI=2.7) compared to A106 (216.2 g a ha^{-1}. For dimethenamid-P, ED_{90} values for A117 and A133 were 150.3 and 63.4 g ai ha^{-1}, respectively, and RI values compared with A106 (39.4 g ai ha^{-1}) were 3.8 and 1.6, respectively. For pyroxasulfone, ED_{90} values were 186.6 and 210.6 g ai ha^{-1} for A117 and A133, respectively, compared with A106 (7.3 g ai ha^{-1}), resulting in RI values of 25.6 and 28.8, respectively. Both accessions A117 and A133 demonstrated reduced sensitivity ($p < 0.0001$) to all Group 15 herbicides compared with A106, based on both ED_{50} (data not shown) and ED_{90} values. These findings indicate that

waterhemp populations recently confirmed resistant to *S*-metolachlor also exhibited cross-resistance to other Group 15 herbicides evaluated in this study, raising concerns about the effectiveness of alternative herbicides within this group. For encapsulated acetochlor and pyroxasulfone, the ED_{90} values exceeded their respective label rates (1,261 and 110 g ai ha^{-1}), indicating strong cross-resistance to both herbicides.

283 - Integrating Metabolomics and Transcriptomics to Dissect 2,4-D Resistance in Waterhemp (*Amaranthus tuberculatus*)

Michael Ozolins[1], Emma Kuhl[1], Patrick J. Tranel[2], Erin Hill[1], Kevin Bradley[3], Todd Gaines[4], Eric Patterson[1]

[1]Michigan State University, [2]University of Illinois, [3]University of Missouri, [4]Colorado State University

Herbicide resistance is one of the greatest treats to the future of sustainable weed control. Among herbicide resistance mechanisms, enhanced herbicide metabolism is of greatest concern because it evolves rapidly, often confers unpredictable cross and multiple resistance across herbicide modes of action. Waterhemp (*Amaranthus tuberculatus*) is one of the world's worst weeds causing extensive yield loss in soybean has evolved resistance to 7 modes of action. A synthetic auxinic herbicide 2,4-dichloro-phenoxy acetic acid (2,4-D) has been a valuable post-emergence herbicide option to control many broadleaf weeds including pigweeds; however, after 2,4-D resistance was first discovered in 2009 it has now spread across soybean growing regions in the Midwest. Past research has showed that 2,4-D resistance in waterhemp is due to cytochrome P450 based enhanced herbicide metabolism. Yet, there are still major unanswered questions: what are the causal P450s and do geographically isolated populations share the same genes responsible for 2,4-D metabolism. To answer these questions, we conducted metabolite profiling and RNA seq on a diverse collection of 2,4-d resistance and susceptible waterhemp germplasm. We identified three major metabolites previously identified in past research 2,4-D conjugated to aspartic acid, 2,4-D-5-*O*-d-glucopyranoside, and 2,4-D-(6′-*O*-malonyl)-5-*O*-d-glucopyranoside as well two previously unidentified metabolites in waterhemp 2,4-D conjugated to glutamate and 2,4-D glucoside. Resistance waterhemp showed greater conversion of 2,4-D into their hydroxylated metabolites when compared to susceptible populations. In our RNA seq study, we found that each resistance population contained a distinct set of overexpressed P450s ranging between 14-18 P450s per population suggesting that that in waterhemp multiple P450w are responsible for the initial hydroxylation. Current work is focused on functionally validating upregulated cytochromes through heterologous expression. Understanding the genetic bases of 2,4-D resistance allows us to help growers management 2,4-D resistance.

284 - Geographic Variation in Herbicide Sensitivity of *Sorghum halepense* (Johnsongrass) Biotypes Across the United States.

Connor Purvis[1], Michael Ozolins[1], Sarah Robinette[1], Eric Patterson[1], Erin Burns[1]

[1]Michigan State University

Herbicide resistance evolution in weed species presents substantial problems in management and protecting crop yields. Identifying and monitoring resistant weeds is also important for informing management recommendations to mitigate factors that contribute to resistance evolution and spread. *Sorghum halepense*, johnsongrass, is a highly successful allotetraploid perennial weed species that has evolved resistance to four different sites of actions. Lack of genomic resources for *S. halepense* has hampered the development of molecular markers for resistance diagnostics and constrained understanding of resistance mechanisms. Therefore, this research had four objectives: 1) quantify herbicide sensitivity variation in geographically diverse *S. halepense* biotypes, 2) develop universal molecular assays that can identify target-site resistance (TSR) mechanisms in *S. halepense*, 3) investigate evidence of non-target-site resistance (NTSR) in biotypes lacking TSR mutations, and 4) assess patterns in herbicide sensitivity associated with geographic and land-use factors. We screened 46 *S. halepense* biotypes across the United States to nicosulfuron (ALS), glyphosate (EPSPS), and clethodim (ACCase) to quantify herbicide sensitivity. Nicosulfuron resistance was the primary resistant phenotype characterized with 24% (n=11) identified as resistant. One biotype was resistant to glyphosate, while clethodim remained effective for all biotypes evaluated. Notably, nicosulfuron resistance varied widely; resistant biotypes ED_{50} values ranged from 66 to > 4,160 g ha^{-1} (1x = 65 g ha^{-1}), representing a more than 60-fold difference among resistant biotypes. The lone glyphosate-resistant biotype had an ED_{50} value of 1,036 g ae ha^{-1} (1x = 867 g ae ha^{-1}). Three novel primer sets were successful in amplifying resistance-associated regions simultaneously in both subgenomes for *ALS* and *EPSPS*, enabling clear TSR mutation identification. Interestingly, we observed both TSR and NTSR in nicosulfuron resistant biotypes, and found no evidence of TSR in the glyphosate resistant biotype. For nicosulfuron, the Trp574 substitution was the sole TSR mechanism in 64% (n=7) of resistant biotypes; biotypes lacking TSR exhibited resistance reversal following malathion pretreatment, suggesting involvement of a cytochrome P450-mediated NTSR mechanism. For glyphosate, LC-MS provided putative evidence of altered glyphosate fate; at seven and ten days after application, concentrations were 48% and 50% lower in the resistant compared with a susceptible biotype. Multivariate analyses of herbicide sensitivity patterns associated with geographic and land use factors highlighted latitude as the sole environmental variable with significant association. The primary variation was driven by highly resistant biotypes from Michigan, whereas several southern biotypes had comparatively moderate resistance levels. Land use alone was a poor predictor of herbicide sensitivity patterns, as resistance was observed in both agricultural and non-agricultural biotypes. Nevertheless, increasing geographic sampling, resistance phenotypes, and thorough land use information can further pinpoint factors influencing herbicide resistance spread. This research advances our understanding of herbicide resistance in *S. halepense*. Moreover, these findings provide novel molecular markers for accurately detecting TSR mechanisms in a genetically complex polyploid weed species. Continued integration of complementary approaches to investigate herbicide resistance across weed species will be essential for improving monitoring and informing proactive management strategies.

285 - Tissue- and Stress-Specific Expression of Cytochrome P450 Monooxygenases in Waterhemp (*Amaranthus tuberculatus*) and Palmer Amaranth (Amaranthus palmeri).

Isabel Noe[1], Alexander Lopez[1], Patrick Tranel[1]

[1]University of Illinois

Cytochrome P450 monooxygenases (CYP450s) are a large and functionally diverse family of enzymes involved in numerous physiological and biochemical processes across living organisms. In plants, these enzymes exhibit broad substrate specificity and play important roles in the metabolism of endogenous and exogenous compounds, including those associated with responses to biotic and abiotic stresses. Herbicides are xenobiotic compounds, and the ability of plants to metabolize these chemicals can contribute to reduced herbicide sensitivity and resistance, as widely documented in several weed species. Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus*) are two closely related and economically important weed species that have evolved resistance to multiple herbicide sites of action, with several reports implicating enhanced herbicide metabolism mediated by CYP450s and glutathione S-transferases (GSTs). The recent availability of reference genomes for both species provides an opportunity to comprehensively identify these enzyme families and investigate their expression patterns across tissues and in response to herbicide exposure and abiotic stresses. The broader objective of this research is to develop a comprehensive expression atlas of CYP450 and GST genes in Palmer amaranth and waterhemp, with the goal of identifying candidate genes potentially involved in herbicide metabolism and broader stress responses. Plants of both species were exposed to five herbicides representing distinct sites of action: fomesafen, mesotrione, 2,4-D, glufosinate, and glyphosate. Abiotic stress treatments included drought and cold, along with a nontreated control. Three tissue types—leaf, root, and shoot apical meristem—were collected for RNA sequencing to characterize tissue-specific and stress-responsive gene expression patterns. This presentation will focus on the diversity and expression profiles of CYP450 genes in Palmer amaranth, highlighting their tissue-specific expression and responses to herbicide exposure and abiotic stresses, with the goal of identifying candidate genes potentially involved in herbicide metabolism and stress responses.

Symposium – Planting Green for Weed Suppression and Ecosystem Services

286 - Planting Green for Weed Suppression and Ecosystem Services

Amit Jhala[1], Sachin Dhanda[2], Sophie Westbrook[3], Sarah Kezar[4], Kurt Vollmer[5], John Wallace[6], Veronica Yurchak[5]

[1]University of Nebraska-Lincoln, [2]South Dakota State University, [3]Kansas State University, [4]University of Wisconsin-Madison, [5]University of Maryland, [6]Pennsylvania State University

The increasing prevalence of herbicide-resistant weeds, coupled with rising production costs and growing emphasis on environmental stewardship, has intensified the need for biologically based weed management strategies. Among these approaches, *planting green*, defined as planting a cash crop into a living cover crop prior to its termination, has gained considerable attention as a promising practice for enhancing weed suppression while simultaneously delivering ecosystem services. By extending cover crop growth into the cash crop planting window, planting green can suppress weeds through resource competition, physical mulching effects, and alterations in the crop microenvironment. In addition to its

weed management benefits, this practice has been associated with improvements in soil health, nutrient retention and cycling, water conservation, biodiversity, soil erosion control, and carbon sequestration, thereby contributing to the development of climate-resilient and sustainable agricultural systems. This symposium will provide a comprehensive examination of the role of planting green in modern crop production systems and its implications for weed management and ecosystem functioning. Presentations by leading researchers will explore the agronomic principles and practical implementation of planting green in corn and soybean production, the ecological mechanisms underlying weed suppression, and the effects of this practice on weed seed rain, fecundity, and soil seedbank dynamics. The symposium will also address the influence of planting green on herbicide fate and environmental outcomes, providing insights into interactions among cover crops, herbicides, and ecosystem processes. Importantly, speakers will critically evaluate the limitations and risks associated with planting green, including circumstances under which the practice may reduce crop performance or fail to achieve desired agronomic outcomes. To broaden the discussion beyond row-crop systems, the symposium will highlight emerging applications of living cover-based approaches in specialty crop production, including the use of spring-seeded grass cover crops in plasticulture systems and living mulches in vegetable production. These presentations will examine management considerations, system-specific challenges, and trade-offs associated with integrating cover crops into diversified agricultural systems. By bringing together expertise from weed science, agronomy, and agroecology, this symposium will synthesize current knowledge on planting green and identify critical research gaps that limit its broader adoption. The session will foster interdisciplinary discussion among researchers, extension professionals, and industry stakeholders, while providing a framework for future research and outreach efforts. The symposium aims to advance scientific understanding of planting green systems and promote the development of integrated management strategies that enhance weed suppression, strengthen ecosystem services, and improve the long-term sustainability and resilience of agricultural production systems.

287 - Mechanisms of Weed Suppression Under Planting Green

Sophie Westbrooke[1]

[1]Kansas State University

Abstract not available.

288 - Effect of Planting Green on Seed Rain, Fecundity, and Seedbank Dynamics

Sachin Sachin Dhanda[1]

[1]South Dakota State University

Abstract not available.

289 - Challenges and Risks: When Planting Green Can Backfire

Sarah Kezar[1]

[1]University of Wisconsin-Madison

Abstract not available.

290 - Effect of Planting Green on Herbicide Fate and Ecosystem Services

John Wallace[1]

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Abstract not available.

291 - Spring-seeded Grass Cover Crops in Plasticulture Systems

Kurt Vollmer[1]

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Abstract not available.

292 - Living Mulches in Vegetable Production: Trade-offs, Challenges, and Management Strategies

Veronica Yurchak[1]

[1]University of Maryland

Abstract not available.

293 - Planting Green: Summary and Future Research

Amit Jhala[1]

[1]University of Nebraska-Lincoln

Abstract not available.

Extension

294 - Addressing Weed Management Challenges in Wisconsin High Oleic Soybean Cropping Systems Through On-Farm Research and Education

Daniel Smith[1], Joao Pedro Smaniotto[1], Ryan DeWerff[1], Nikola Arsenijevic[1], Ahmadreza Mobli[1], Rodrigo Werle[1]

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Wisconsin dairy farms are interested in growing soybean with high oleic content as a strategy to lower reliance on external feed sources to increase milk fat yield. Increased milk fat often results in increased income and increased profitability. These benefits introduce the challenge of integrating soybean into forage-based crop rotation. In a forage-based cropping system, weeds are managed primarily through the harvest of the crop every thirty days for alfalfa or a simple one pass herbicide program for corn relying often on decades old herbicide chemistry. Since soybean canopy closure and harvest timing both occur later in the growing season compared to corn, troublesome weeds like waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer) and giant ragweed (*Ambrosia trifida* L.) can greatly reduce yield and soybean quality; both key to profitable high oleic soybean production. Weeds in forage crops become feed, in soybean, uncontrolled weeds decrease grain yield and protein resulting in feed loss and slow the harvest operation. Thus, weed management education for dairy farmers growing soybean for the first time is critical. An additional challenge to this system is herbicide rotational restrictions for alfalfa. For instance, a common soybean herbicide for waterhemp control, fomesafen, has an 18-month rotational restriction for alfalfa, making this herbicide more challenging to incorporate into a forage crop rotation. High oleic soybean weed control programs are dependent upon variety and maturity group as some are resistant only to glyphosate while others are resistant to glyphosate, glufosinate, and 2,4-D. On-farm trials were established near Lone Rock, Beaver Dam, and West Bend, Wisconsin. These sites offered different had soil types (sandy loam, silt loam, and muck), tillage (no-till into living cereal rye cover crop, strip-till, and no-till), soybean row spacing (28.1cm, 50.8cm and 76.2cm), and rotational crops (alfalfa, potato, seed corn). Small plots (3m by 9.1m) were established in a randomized complete block design with four replications. The plots demonstrated preemergence herbicide programs that could provide long lasting weed control in a dairy forage rotation. The postemergence weed control program of lactofen, bentazon, and clethodim was chosen to demonstrate weed control options regardless of crop herbicide tolerance traits. These studies helped Wisconsin dairy farmers and agronomists better understand the need for a two-pass herbicide program which they are not accustomed to and to showcase how detrimental weeds can be in a soybean grain system. Since all the herbicides used were not crop trait dependent, this trial also brought value for farmers struggling to control weeds in non-GMO soybean. Trial results have been shared with host farmers and their agronomists, during a dairy outreach program with 147 dairy farmers, nutritionists, and agronomist attendees, and via an online video. Adding high oleic soybean to dairy forage rotations adds unique opportunities for farmers to diversify their weed management strategy. Future research could include adding ryelage forage crop for suppression of winter annual and early

emerging summer annual weeds, and using different herbicides, application timings, and modes of action in a high oleic soybean system.

295 - Weed Management Practices and Costs in Commercial Field Nursery Production in North Carolina and Tennessee

Sam Marshall[1], Anthony Witcher[2]

[1]NC State University, [2]Tennessee State University

Weed management is an integral part of field nursery production, yet growers vary considerably in the weeds they target, how they manage them, and the herbicides they use. Through on-farm trials, land-grant university professionals can demonstrate efficacy of various herbicides (pre and post-emergent herbicides) and develop recommendations to help growers improve weed control. However, less is known about the costs associated with weed management programs growers use. This talk will present the results from grower interviews conducted across North Carolina and Tennessee in the summer of 2026 to assess weed management practices and associated costs, and compare current grower practices with Extension-based recommendations developed through on-farm trials. We will discuss some results from on-farm trials and future directions for research relative to weed management in ornamental field nursery systems.

296 - Can Spray Drones Provide Comparable Weed Control to Ground Boom Equipment in a Full-Season Herbicide Program?

Maria Carolina CR Souza[1], Emmanuel G Cooper[1], Kamryn R Frost[1], Daniel Q Zhu[1], Leonard B Piveta[1], Julie M Young[1], Bryan G Young[1], Thomas R Butts[1]

[1]Purdue University

Little to no research is available evaluating full-season herbicide programs (preemergence + postemergence applications) using spray drones. To address this research gap, the aim of this study was to assess a full-season corn (*Zea mays* L.) herbicide program applied using a spray drone or a ground-based sprayer. A field experiment was conducted in 2025 and 2026 in West Lafayette, IN, and was arranged as a completely randomized block design with four replications and seven treatments. Treatments consisted of a nontreated control; a spray drone (DJI Agras T30) with two assumed swath widths (9.1 and 4.6 m) and two droplet size classifications (Fine and Coarse, using XR110015 and AIXR110015 nozzles, respectively); and a ground sprayer (Capstan PinPoint 3 pulse-width modulation sprayer) with a 9.1-m boom width and Fine or Coarse sprays (using ER11004 and MR11004 nozzles, respectively). All drone treatments were calibrated to deliver 28 L ha^{-1} from a height of 3.7 m above the crop. The ground sprayer operated at a carrier volume of 140 L ha^{-1} with the boom positioned 60 cm above the crop. All treatments except the nontreated received the same preemergence (210, 13, 50, and 449 g ai ha^{-1} of atrazine, bicyclopyrone, mesotrione, and *S*-metolachlor, respectively) and postemergence (1,262 and 656 g ae/ai ha^{-1} of glyphosate and glufosinate, respectively) herbicides, along with 1,3,6,8-pyrenetetrasulfonic acid (PTSA) dye (600 µg mL^{-1}). Acetate cards were placed every 76 cm along an 11-m-long transect,

approximately 15 cm above the ground surface, and perpendicular to the sprayer travel path to assess spray deposition. Weed density was assessed before and after application using 0.09-m² quadrats distributed across the swath at 76-cm intervals. Visual weed control was evaluated weekly at the plot centers. Drone deposition patterns exhibited a non-uniform, bell-shaped distribution and typically exceeded the maximum deposition observed with the ground sprayer, which maintained a more uniform deposition pattern across the entire swath. Although two different route spacings were set in the drone remote controller, little difference was observed in the actual swath width. However, the wider route spacing produced higher deposition peaks beneath the flight paths than the narrower spacing. Two weeks after the postemergence application, all treatments provided ≥ 91% visual control of *Echinochloa crus-galli* (L.) P. Beauv. and *Setaria faberi* Herrm., except for the spray drone treatment with a 4.6-m swath width and Fine spray in 2026 (82%) and Coarse spray in 2025 (88%) and 2026 (84%). At the same evaluation, *Chenopodium album* L. control ranged from 93% to 99% in 2025 and from 92% to 99% in 2026. These results indicate that spray drones can provide weed control comparable to ground sprayers at times when used in a full-season herbicide program. However, effectiveness may vary based on weed species, and conducting swath testing rather than relying solely on the settings entered in the spray drone controller is foundational to avoid overdosing and ensure proper overlap between spray passes.

297 - Using Field Demonstration Plots to Increase Confidence with Integrated Weed Management

Josh Kamps[1]

[1]UW-Madison Division of Extension

Previous field research has shown that the decision of cereal rye, (*Secale cereale*), termination timing within a “planting green” soybean, [*Glycine max* (L.) Merr.], establishment system directly impacts the level of weed suppression achieved and the resulting soybean yield potential. To provide Extension field day learning opportunities, increase the visibility of this integrated weed management practice, and to collect field length yield data by treatment, a cereal rye termination timing trial in soybean was established. The trial design was based on the work of current and former members of the WiscWeeds Team and was established at the Rock County Farm in Janesville, WI. Following corn grain harvest, cereal rye was no-till seeded at a rate of 67.25 kg ha^{-1} on November 22, 2025, and soybeans were “planted green” with a John Deere mounted planter at 76-cm rows and 345,947 seeds ha^{-1} on May 5, 2026. Cereal rye was terminated at four different soybean growth stage timings identified as T1 (At planting), T2 (VE), T3 (VC), and T4 (V1). Cereal rye maturity, height, and dry matter biomass were collected at the time of termination and these values increased steadily during the 32 days between T1 and T4 treatments. Cereal rye was terminated with an application of 2.19 L Roundup PowerMax3 and 2.8 kg AMS ha^{-1} at the spray rate of 140 L ha^{-1}. Rainfall was short during the month of May at the farm with only 7.62 mm of rain recorded. Cereal rye continued to develop due to soil moisture available deeper in the soil profile, while soybean growth and development was stagnant with many seeds not germinating until rainfall returned in June. Ahead of the post-emergence herbicide application, a regional weed management field day was organized with support of the WiscWeeds Team and UW-Madison Division of Extension at the Rock County Farm. Field day participants which included farmers, agronomists, and crop consultants, experienced the weed suppression value provided by increased levels of cereal rye

biomass. Weed counts were collected by treatment ahead of a post-emergence herbicide application on June 27, 2026. Ahead of soybean harvest on October 20, 2026, weed counts were collected by treatment and soybean stand counts were recorded. Final soybean stands were low across the plot but similar between treatments with an average of 175,441 plants ha^{-1}. The reduced soybean stands were most likely due to dry soil conditions during the month of May which reduced soybean germination rate. Average soybean yields across three replications per treatment were T1-4,245, T2-4014, T3-3,842, and T4-3,533 kg ha^{-1}. The next steps for this project are to finalize weed count data, analyze yields, and prepare a presentation to share during winter regional Extension programs. The trial will be conducted again in 2027 with the addition of a no cover crop treatment and a fourth replication per treatment.

298 - Evaluation of Metribuzin in Corn: A North Central Extension Effort

Eric Jones[1], Jill Alms[1], David Vos[1], Isabelle Aicklen[2], Kevin Bradley[3], Erin Burns[4], Thomas Butts[5], Leonard Piveta[5], Alyssa Essman[6], Alyson Godwin[6], Wesley Everman[7], Karla Gage[8], Eric Miller[8], Sarah Ganske[9], Isaac Goncalves[9], Aaron Hager[10], Logan Miller[10], Caleb Wepprecht Wepprecht[10], Joseph Ikely[11], Amit Jhala[12], Travis Legleiter[13], Debalin Sarangi[14], Rodrigo Werle[15], Ryan DeWerff[15]

[1]South Dakota State University, [2]University of Guelph, [3]University of Missouri, [4]Michigan State University, [5]Purdue University, [6]Ohio State University, [7]Iowa State University, [8]Southern Illinois University, [9]Kansas State University, [10]University of Illinois, [11]North Dakota State University, [12]University of Nebraska, [13]University of Kentucky, [14]University of Minnesota, [15]University of Wisconsin

Field experiments were conducted at nine locations (Illinois, Indiana, Iowa, North Dakota, Ohio, South Dakota and Wisconsin) in 2025 and sixteen locations (Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, Ontario, North Dakota, Ohio, South Dakota and Wisconsin) in 2026 across the North Central region to determine the effect of metribuzin on corn safety, -yield and waterhemp (*Amaranthus tuberculatus*) management. Metribuzin was applied at 0, 70, 140, 210, 280, 350 and 420 g ai ha^{-1} at planting. Atrazine was applied at 560 and 1120 g ai ha^{-1} as well for a comparison. Average corn injury was never greater than 1% with all tested treatments. Waterhemp control on average ranged from 39 to 85% with the tested metribuzin rates. Both atrazine rates provided approximately 45% waterhemp control, on average. Corn yield ranged from 11568 to 112407 kg ha^{-1} with the tested metribuzin rates. Corn yielded similar to all tested metribuzin rates when treated with atrazine at both rates (11509 to 12082 kg ha^{-1}). All tested herbicide treatments yield greater than the nontreated. The results of this experiment provide evidence that metribuzin provides similar corn safety and yield as atrazine but waterhemp control was greater with select metribuzin rates compared with both atrazine rates.

Alternative and Emerging Technological Weed Management

299 - Novel approaches for precision weed management

Vijay Singh[1], Fatemeh Esmaeilbeiki[1], Akashdeep Brar[1], Gaganjot Sodhi[1], Prudhvi Vulchi[1], Daniel Martin[2]

[1]Virginia Tech, [2]Pluvium LLC

Uncrewed aerial systems (UAS) are increasingly used for weed mapping, herbicide application, and cover crop seeding in row-crop production. Recent studies conducted at Virginia Tech's Eastern Shore Agricultural Research and Extension Center, Painter, VA, evaluated UAS-based preemergence (PRE) and postemergence (POST) herbicide applications in comparison with backpack and tractor sprayers. While PRE and early POST UAS applications provided weed control similar to ground applications, late-POST UAS applications provided 20 to 25% greater weed control, attributed to rotor-generated air circulation and greater spray coverage and herbicide deposition in the crop canopy. Additional studies evaluated drift-reducing agents (DRAs) in glufosinate applications with a DJI T50 UAS (37.4 L ha^{-1}) and a CO_2-pressurized backpack sprayer (140 L ha^{-1}). DRAs increased droplet size on both platforms; in backpack applications, glufosinate plus Liberate produced the largest volume median diameter (387.1 µm), and in UAS applications, InterLock and WeatherGard increased the volume median diameter by approximately 90 µm at the 250-µm droplet-size setting. Water-sensitive-paper deposit features combined with machine learning (XGBoost) distinguished DRA-treated deposits from controls (accuracy 0.81; ROC-AUC 0.86), and separate machine learning models were developed to predict spray drift from UAS applications. UAS were also evaluated for aerial cover crop seeding, and the impact of irrigation and tillage on cover crop emergence and biomass production.

300 - Deep Learning-Based Detection of Palmer Amaranth (Amaranthus palmeri) in No-Till Dryland Grain Sorghum of Western Kansas: Implications for Real-Time and Edge-Based Weed Management

Jeremie Kouame[1], Atong Akom[1], Augustine Obour[1], Anita Dille[1], John Holman[1]

[1]Kansas State University

Palmer amaranth [*Amaranthus palmeri* (S.) Wats.] is one of the most problematic weeds in dryland production systems in western Kansas, and effective control requires herbicide programs targeting multiple sites of action, making broadcast herbicide application costly. Site-specific weed management (SSWM) strategies can help farmers in western Kansas to improve control and reduce herbicide input and application costs. Effective use of deep learning techniques, combined with computer vision, can discriminate Palmer amaranth from grain sorghum but has not been used for weed detection in grain sorghum in western Kansas. Images of natural populations of early-season Palmer amaranth were collected aerially and at ground level during summer 2025 in grain sorghum fields established in no-till production systems in Hays, KS. Five hundred and eighty-two of the collected images were annotated and complemented with 1622 publicly available annotated Palmer amaranth images to train five variants of the “You Only Look Once” (YOLO) object detection model (YOLOv8n, YOLOv8s, YOLOv8m, YOLOv8l, and YOLOv8x) to locate/identify Palmer amaranth in field images and compare the

effectiveness of the model variants for Palmer amaranth detection. Precision, Recall, F1-score, mean average precision at 0.5 intersection over union (IoU) (mAP0.5), and the stricter mean average precision at 0.5 to 0.95 IoU in increments of 0.05 (mAP0.5:0.95) were used to evaluate the performance of the model variants. Results showed that all YOLOv8 variants achieved strong Palmer amaranth detection, with Precision, Recall, F1-score, mAP0.5, and mAP0.5:0.95 values ≥ 90%, ≥ 85%, ≥ 87%, ≥ 91%, and ≥ 61%, respectively. YOLOv8x achieved the best results across all metrics at 120 epochs with Precision, Recall, F1-score, mAP0.5, and mAP0.5:0.95 values of 96, 96, 96, 99, and 79%, respectively. YOLOv8n had 6, 11, 8, 8, and 18 percentage points lower Precision, Recall, F1-score, mAP0.5, and mAP0.5:0.95 values, respectively. However, YOLOv8x achieved the best results at the cost of higher Giga-floating-point operations (GFLOPS), at 257.8 compared to 8.7, 28.6, 78.7, and 165.2 GFLOPS for the nano, small, medium, and large variants, respectively. YOLOv8x also had more parameters, with 68.2 million compared to 3.2, 11.2, 25.8, and 43.7 million for the nano, small, medium, and large variants. These results suggest that, under dryland no-till field conditions with residue cover, using YOLOv8 is promising for detecting Palmer amaranth when sufficient data are available. Edge deployment of optimized YOLOv8 models, particularly the lightweight YOLOv8n variant, could enable real-time, in-field Palmer amaranth detection to support site-specific herbicide applications while reducing computational requirements and improving the practicality of SSWM systems.

Keywords: Site-specific weed management, Palmer amaranth, grain sorghum, artificial intelligence, deep learning, YOLOv8, mean average precision.

Industry Breakfast and Speaker

301 - 2026-2027 Weather Recap/Future Outlook & El Niño Pattern

Dr. Aaron Wilson[1]

[1]The Ohio State University

Abstract not available.

General Session

GS1 - Welcome to the Joint NCWSS/NEWSS Annual Meeting

Dr. Fritz Koppatschek[1]

[1]ABG AG Services

Abstract not available.

GS2 - From Discovery to Delivery: USDA's Extramural Research Investments

Dr. Jaye Hamby[1]

[1]USDA National Institute of Food and Agriculture

Abstract not available.

GS3 - NEWSS Presidential Address

Dr Katelyn Venner[1]

[1]BASF Corporation

Abstract not available.

GS4 - NCWSS Presidential Address

Brett Miller[1]

[1]Syngenta Crop Protection

Abstract not available.

GS5 - Washington, DC, Science Policy Update

Lee Van Wychen[1]

[1]Weed Science Society of America

Abstract not available.

GS6 - Program Announcements

Dr. Fritz Koppatschek[1]

[1]ABG Ag Services

Abstract not available.

GS7 - Remembering NCWSS Members and Friends

Chad Lammers[1]

[1]Midwest Research Inc.

Abstract not available.

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