‘Unofficial’ NCWSS 2025 Proceedings

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Poster Section – Cover Crops & Integrated Weed Management

1 - Cereal Rye, Termination Timing and Herbicide Programs: Evaluating Waterhemp Management in a Corn-Soybean Rotation

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Waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] has become one of the most difficult weeds to control in corn (*Zea mays* L.) and soybean (*Glycine max* L.) production systems in Ohio and throughout the Midwestern United States due to its prolific seed production and increasing resistance to herbicides. A two-year field experiment (2024-2025) was conducted in Ohio at the Western Agricultural Research Station in South Charleston, OH, to evaluate the effects of: 1) a cereal rye cover crop, 2) rye termination timing, and 3) herbicide programs and their effects on waterhemp density and cash crop parameters in a corn (2024)- soybean (2025) rotation. This trial was conducted at the Western Agricultural Research Station in South Charleston, Ohio using a Split-Plot Randomized Complete Block Design with 16 treatments and 4 replications. Treatments included: 1) presence or absence of cover crop (67 kg seeds ha^{-1}), 2) early or late termination timing, and 3) herbicide program (PRE only, PRE + POST simple, PRE + POST comprehensive, and no herbicide). For corn, rye was terminated 14 or 7 days before corn planting, and for soybean, rye was terminated 7 days before or 14 days after soybean planting. Data were analyzed with the GLIMMIX procedure in SAS 9.4. Weather conditions varied considerably between the two years, with 2024 characterized by drought and 2025 by above-average rainfall. Results indicated that the herbicide program was the most consistent factor influencing waterhemp density and crop yield in both years. Treatments with PRE + POST herbicide programs resulted in greater weed control and higher yields compared to plots treated with PRE only or untreated. In both crops, plots without herbicides had the highest waterhemp densities and lowest yields, confirming the essential role of chemical control. The cover crop of rye had variable effects. In 2024, the presence of rye reduced corn yield to 9305 kg ha^{-1} compared to 11336 kg ha^{-1} in plots without cover crop but did not affect soybean yield in 2025. In 2024, a negative linear relationship was observed between rye biomass and waterhemp density 21 days after PRE application, indicating that a greater amount of biomass improved waterhemp suppression. In 2025, early cover crop termination resulted in higher waterhemp densities compared to late termination. In 2025, it was observed that plots without herbicides and early termination resulted in higher waterhemp densities (13 plants m^{-2} 21 days after PRE and 26 plants m^{-2} 14 days after POST), while plots with comprehensive PRE and POST with any termination timing resulted in almost complete control. Overall, integrating a rye cover crop with PRE + POST herbicide programs provided the most reliable strategy for controlling waterhemp in corn and soybean rotations. Although cover crop biomass contributed to weed suppression, herbicide programs remain the primary tool for effective control. These results highlight the importance of adjusting termination timing and management strategies based on seasonal weather conditions and cash crop to optimize both weed control and crop productivity in Midwest production systems.

2 - Planted Green: When to Spray?

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Herbicide-resistant weeds are a significant challenge for Mid-Atlantic soybean farmers. To address this issue, farmers are increasingly using rye (*Secale cereale*) cover crops to improve weed control. The effectiveness of weed suppression is closely tied to the amount of rye biomass produced, with greater biomass lead often resulting in better control. However, large biomass of cover crops can interfere with planter performance, affecting proper seed placement and adequate seed furrow closure. This experiment compared "planting green" when rye was in the late boot stage (less biomass to plant through) compared to the more conventional time of rye heading. In addition to the rye stage, three termination timings were compared. This study was conducted in a field with a heavy weed seedbank *Amaranthus palmeri* (Palmer amaranth), *Ipomoea hederacea* (ivyleaf morningglory), *Digitaria sanguinalis* (large crabgrass), and *Panicum dichotomiflorum* (fall panicum). The experimental design was a randomized complete block with three-factor factorial arrangement of treatments, and four replications. Main effects were cereal rye stage at planting (late boot stage or heading), termination timing (at planting, 2 weeks after planting [WAP], or 3 WAP), and PRE herbicide application (with or without pyroxasulfone). Cereal rye was planted October 28, 2024, and Enlist 3 soybean (*Glycine max* 'IS3901E3S') were planted (76-cm rows, 296,000 seeds ha^{-1}) on April 24 or May 16, 2025, to correspond with the two rye stages. Glyphosate plus 2,4-D choline was applied at the rye termination timing, with or without pyroxasulfone. Glyphosate plus glufosinate was applied 6 to 7 WAP across all treatments. Cereal rye biomass was 315, 393, and 567 g m^{-2} on April 24, May 8, and May 13 (corresponding with first planting date, 2 WAP and 3 WAP). This demonstrates the rapid accumulation of rye biomass during the stages of stem elongation to complete head emergence. Soybean stand counts were higher with the earlier planting date (23.5 versus 22.3 plants m^{-1} row). Soybean heights were shorter for the later planting date for most of the season but were comparable by mid-August. Weed densities were low in all treatments, despite the field used for weed control trials for multiple years. Adjacent trials without cover crops had significant weed densities. Soybean yield did not differ among treatments, yet there was a trend for higher yield with the earlier planting date. Whether this was due to increased stand, earlier planting date, or less rye/soybean competition during crop establishment cannot be determined. Delaying rye termination date, as late as 3 WAP, did not impact yield ($P>F$ 0.32). Additional research is needed to better understand the nuances of cereal rye management to enhance weed control. But this initial trial was encouraging to see that a wide planting-window with planting green, accommodating the trend towards earlier planting date and allow flexibility to manage soil moisture; and allowed for rye to recover from damage due to planting and provide better residue coverage for more uniform weed suppression.

3 - Got Herbicide Resistant Weeds?

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Canada thistle (*Cirsium arvense* L.) is a creeping perennial and a designated noxious weed under Ohio law. The plant spreads via rhizomes and seed causing yield losses and recurrent infestations in arable land. Effectively controlled by applications of glyphosate, it is difficult to manage in areas where glyphosate use is impractical. Current management strategies include fall applications, post-emergence herbicides, spot spraying glyphosate and diversifying crop rotations. These limitations and the general difficulty in controlling Canada thistle have prompted interest in non-chemical methods such as electric weed control, which kills plants by passing an electric current through their tissues to rupture cells. Common lambsquarters (*Chenopodium album* L.) and waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] were also evaluated for their responses to continuous-contact electrocution. It is important to study the effects of non-chemical weed control on both annuals and perennials to better understand alternative methods for weed management, especially for organic operations. Lambsquarters is very problematic in landscape and garden settings, while waterhemp is one of the most difficult weeds to manage in the Midwest, especially considering the species' prolific seed production and development of multiple herbicide-resistance. This study examines continuous contact electrical weed control delivered via a two-pronged device to plant stems. This management practice offers a potential year-round solution for managing Canada thistle, lambsquarters and waterhemp without the timing restrictions or off-target movement concerns of chemical treatments. The project explored the effectiveness of an electrical approach using rechargeable electric cattle prods capable of delivering a continuous 12,000-volt discharge. An experiment was set up in a completely randomized design to evaluate the effects of electrocution with two factors: species (Canada thistle, waterhemp and common lambsquarters) and electrocution timing (10, 20 and 30 seconds). Students in HCS 3100 applied treatments to the respective species at the listed intervals. To evaluate treatment effects, visual ratings (0-100%) were recorded immediately at these intervals in days after treatment (0 DAT, at one week (7 DAT) and two weeks after treatment (14 DAT). At the time of treatment, all lambsquarters and waterhemp were effectively killed with 99-100% control. Canada thistle had greater control the longer the treatment was applied, with 64, 83 and 90% control at 10, 20 and 30 seconds, respectively. One and two weeks after treatment, only the thistle with 10 seconds of treatment was below 90%. Understanding the efficacy of continuous-contact electrocution methods on annual and perennial weeds introduces new avenues of weed control to growers, landowners and homeowners who might not have appropriate spray equipment, for whom the effective control of certain species may be cost prohibitive, or who may want to avoid chemical applications. The study also provides preliminary data for developers of electrical control methods to improve the understanding of current equipment to make it as effective as possible.

4 - Insect and Weed Control with Propane Flaming in Mature Organic Alfalfa

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Weeds and insects (e.g. alfalfa weevil) can significantly decrease both the quality and yield of alfalfa crops. Field studies were conducted on an organic farm near Abie, Nebraska in 2022, 2023, and 2024 with the experiment arranged in a randomized complete block design in 4 replications. Treatments included three alfalfa heights (8 cm, 15 cm, and 30 cm) at the time of flaming and six propane rates (0, 28, 43, 57, 71, and 85 kg ha^{-1}). Plots were 10m long and 15m wide. Weevil feeding injury and weed control ratings (scale 0-100%) were assessed before flaming and 28 days after treatment (DAT). At the same time number of adult and larvae weevils was evaluated in each plot. Total of 20 alfalfa plants were shaken over a 19-liter white bucket to collect any dislodged adults or larvae, which were subsequently counted and recorded. Initial observations at 0 DAT revealed a uniform infestation across all treatments. Prior to flaming, the number of larvae ranged from 19 to 47 per m² at 8 cm alfalfa height, 10 to 19 per m² at 15 cm height, and 2 to 5 per m² at 30 cm height. Number of adults ranged from 0 to 5 per m² at 8 cm and 15 cm heights and were consistently 0 at the 30 cm height. Generally, all propane doses control the alfalfa weevil well. For example, at 8 cm alfalfa height, flamed plots showed a substantial reduction in weevil numbers, with an average of 0 to 3 weevils per square meter and feeding injury between 0% and 30%, compared to 11 weevils and 40% injury in the non-flamed plots. At 15 cm height, weevil counts in flamed plots were consistently zero, with feeding injuries between 0% and 1%, compared to 5% in untreated check and 5 individuals per m^2. At 30 cm height, weevil numbers were already low at 0 DAT, and no post-flaming weevils were observed, likely due to the end of their life cycle. Present weed species were yellow mustard (*Sinapis alba* L,) and dandelion (*Taraxacum officinale* (L.) Weber ex F.H.Wigg). Weed control ranged from 40% to 90%, with higher propane doses and earlier flaming timings providing better control. Overall, results suggest that propane flaming effectively reduced alfalfa weevil infestations and suppressed weeds, demonstrating its potential as a practical, non-chemical control option for organic alfalfa production systems.

5 - Evaluating Winter Barley as a Cover Crop for Summer Annual Weed Suppression

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Winter barley (*Hordeum vulgare* L.) is a promising alternative to cereal rye for weed suppression due to its allelopathic properties, lower biomass production, and shorter stature, which may facilitate ease of cash crop planting while maintaining effective weed suppression. This study evaluated winter barley as a cover crop for suppressing waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer) and giant ragweed (*Ambrosia trifida* L.) under different termination timings and with or without pre-emergence (PRE) herbicide application. The experiment was conducted at the Agronomy Research Center at Southern Illinois University in Carbondale, IL, during fall 2024 through summer 2025. A randomized complete block design was used in a 3×2×2 factorial arrangement with four replications. Treatments included three barley termination timings: seven days before soybean planting (-7 DAP), at planting (0 DAP), and seven days after planting (+7 DAP), combined with the presence or absence of a PRE herbicide treatment. Each plot measured 3 m × 12 m. Plots without winter barley were included for comparison across all termination timings. Winter barley was planted on October 15, 2024. On November 6, 2024, seeds of waterhemp and giant ragweed were introduced in 0.25 m^2 quadrats in each plot. Barley was terminated using glyphosate (1,260 g ae ha^{-1}) plus 2,4-D choline (1,070 g ae ha^{-1}). The PRE herbicide treatment consisted of chloransulam (14.33 g ai ha^{-1}) plus sulfentrazone (79.8 g ai ha^{-1}), applied immediately after soybean planting. A post-emergence (POST) treatment of glyphosate (1,260 g ha^{-1}), 2,4-D choline (1,070 g ae ha^{-1}), and S-metolachlor (1,700 g ai ha^{-1}) was applied 21 days after planting (DAP). Dry biomass of barley was measured at each termination date. Weed density was assessed 21 and 42 DAP. Data were analyzed using a generalized linear model (GLM) with a negative binomial distribution in R, with mean separation by Tukey-adjusted *emmeans* at a 0.05 alpha level. At 21 DAP, waterhemp emergence was reduced in all plots containing barley. Additionally, all treatments that received a PRE were statistically similar, regardless of the termination timing; these treatments had fewer waterhemp than plots without PRE terminated 7 days prior to planting (-7 DAP) or at planting (0 DAP). Treatments receiving PRE terminated prior to plant (-7 DAP) and at planting (0 DAP) were not statistically different from plots terminated post planting (7 DAP) without a PRE. Giant ragweed emergence at 21 DAP was reduced in treatments containing winter barley or a PRE herbicide application. At 42 DAP, the presence of winter barley and PRE herbicide application reduced the establishment of waterhemp, while only the presence of winter barley reduced the establishment of giant ragweed. Winter barley residue and the use of a PRE effectively suppressed both waterhemp and giant ragweed. Plots containing winter barley residue still maintained weed suppression at 42 DAP, independent of barley termination timing. These findings indicate that winter barley may serve as a viable alternative cover crop for integrated weed management in soybean production systems.

6 - Effect of Fall-planted Cover Crop and Tillage on Management of *Ambrosia* spp. and Soybean Yield

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With the rapid development and spread of herbicide-resistant weeds, it is essential to consider integrated weed management strategies that combine chemical and non-chemical approaches. Field experiments were conducted in 2024 and 2025 at the University of Minnesota's Northwest Research and Outreach Center near Crookston, MN, and the Southern Research and Outreach Center in Waseca, MN, to evaluate the effect of cultural (cover crop) and mechanical (tillage) weed management practices combined with herbicide treatments on the control of common ragweed (*Ambrosia artemisiifolia* L.) and giant ragweed (*Ambrosia trifida* L.), and soybean [*Glycine max* (L.) Merr.] yield. The treatments were arranged in a split-plot design with four replications. The main plot factors included tillage (no-tillage, chisel plow in the fall + field cultivator, and strip tillage in the fall) and cover crops (cereal rye planted at 67 kg ha^{-1} in the fall) treatments. The subplot factors included no herbicide treatment, a burndown treatment, and preemergence (PRE) herbicide application. At Crookston in 2024, integrating no-tillage or light tillage (in the fall) with cover crop, conventional tillage (chisel plow in the fall and field cultivator in the spring), and strip tillage (in the fall) with PRE provided at least 95% control of common ragweed, reducing its density to ≤ 5 plants m^{-2} at 42 days after planting. At Waseca in 2025, PRE treatments with conventional tillage and cover crop with light or no tillage, along with a burndown treatment in conventional tillage, provided ≥ 93% control of giant ragweed and reduced density to ≤ 4 plants m^{-2} at 28 days after planting. Overall, treatments that included PRE herbicides along with cover crop or tillage treatments showed better control of both common and giant ragweed than burndown or no herbicide, highlighting the importance of integrating effective cultural and chemical methods for managing ragweed species in soybean.

7 - Interactive Effect of Cereal Rye (*Secale cereale*) Termination Timing and Soil Residual Herbicide Application on Waterhemp (*Amaranthus tuberculatus*) Control in Soybeans

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Waterhemp (*Amaranthus tuberculatus* Moq. Sauer) remains one of the most persistent and competitive weeds in U.S. soybean production due to its resistance to multiple herbicide sites of action. Integrating cover crops with residual herbicide programs provides a promising pathway to mitigate this resistance and reduce early-season weed pressure. 'Planting green', defined as delaying cover-crop termination until or after cash-crop planting, has been proposed to enhance suppression through maximizing residue cover. This study evaluated the combined effects of cover-crop termination timing and residual herbicide application on waterhemp density and biomass in 2023 and 2024 at Southern Illinois University research farms. Field experiments followed a randomized complete block design with a 2 × 3 factorial arrangement of treatments: residual herbicide (Y: applied or not) and cover-crop termination timing (CC: 14 days pre-plant [14 DPP], 1 day after planting [1 DAP], or no cover crop [No_CC]). Soybeans with Enlist® technology were planted in 30-inch rows at 370,657 seeds/ha^{-1}. Cereal rye (*Secale cereale L.*) biomass averaged 70-76 g 0.25 m^{-2} prior to termination. Waterhemp density was measured at 28 days after planting (28 DAP), R1, and R6, with yield recorded at maturity. Data were analyzed using linear mixed models with replication as a random effect and fixed effects of CC, Y, and their interaction. In 2023, waterhemp suppression was strongly influenced by both factors ($P < 0.05$). At 28 DAP, significant CC × Y interaction ($P = 0.04$) indicated that delaying rye termination enhanced suppression even in the absence of residual herbicide. By R1, cover-crop timing was highly significant ($P < 0.001$), with the 1 DAP treatment producing the lowest waterhemp density (2.56 plants m^{-2}). At R6, both CC ($P = 0.003$) and Y ($P = 0.03$) remained significant, confirming that ‘planting green’ maintained suppression through late reproductive stages. Soybean yield was greatest in the 1 DAP treatment (1,606 kg ha^{-1}), exceeding No_CC by over 47%. In 2024, herbicide application had the strongest effect on waterhemp across all assessment timings ($P < 0.001$ at 28 DAP; $P = 0.052$ at R1). Although cover-crop timing effects were weaker, 1 DAP consistently trended toward lower densities and biomass. No significant CC × Y interaction was detected, suggesting greater environmental variability than in 2023. Across both years, waterhemp populations were significantly reduced in treatments with delayed rye termination and residual herbicide use. ‘Planting green’ consistently improved early-season suppression and maintained lower densities through canopy closure without compromising yield. These findings demonstrate that delaying cereal rye termination until or after soybean planting effectively suppresses waterhemp while maintaining soybean productivity in southern Illinois. Integrating ‘planting green’ with residual herbicides provides a sustainable and complementary strategy for managing herbicide-resistant waterhemp populations.

8 - Impact of Cereal Rye Cover Crop Termination Time on Corn Yield in Planting Green Systems

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The integration of a cereal rye cover crop into cash crop rotations continues to be of interest to Wisconsin farmers. Increased adoption is likely being driven by several benefits including: soil erosion mitigation, weed suppression, nutrient management, and payment programs for planting a cover crop. However, many beneficial elements of cereal rye as a cover crop require large amounts of green biomass which can cause challenges in establishing and protecting yield of the subsequent cash crop. One of the most critical decisions facing corn producers is when to terminate cereal rye. To address this question, a two-year study (2023, 2024) at Arlington, WI evaluated six cereal rye termination timings based on corn growth stage: 10-14 days preplant, at plant, at germination, VE, V1, and V2. Cereal rye was terminated with an application of glyphosate (1,261 g ae ha^{-1}). A residual herbicide program, mesotrione (179 g ai ha^{-1}) + *S*-metolachlor (1602 g ai ha^{-1}) + bicyclopyrone (45 g ai ha^{-1}), was also included at the time of cereal rye termination to provide early season weed control. Corn was planted in early May at 88,920 seeds ha^{-1}. 45 kg ha^{-1} of nitrogen was applied as 32-0-0 urea ammonium nitrate liquid fertilizer with the planter. The remaining balance of nitrogen based on UW-recommendations for our research site (155 kg ha^{-1}, 2024 and 167 kg ha^{-1}, 2025) was side dressed as 46-0-0 granular urea around the V4 to V6 corn growth stage. Delaying cereal rye termination resulted in greater cover crop biomass accumulation. Averaged across years, cereal rye biomass at the pre-plant termination was ~2,200 kg ha^{-1} and 3,500 kg ha^{1} at corn planting. By the time corn began to emerge, average cereal rye biomass was ~6,200 kg ha^{-1}, an increase of 100% from the time of corn planting. It is important to note that cereal rye was drilled in late September, which explains the high biomass accumulation observed at corn planting in this experiment. Corn grain yield began to significantly decline when termination occurred after the VE (spiking) corn growth stage. A yield reduction of 15 and 20 percent was observed when termination was delayed from VE to V1 and V2, respectively. Yield loss is likely due to increased competition with the living cereal rye at the early corn growth stages and potential nitrogen tie up in these high cereal rye biomass treatments. A slight reduction in corn plant population at harvest as cereal rye termination was delayed past corn seed germination was also observed, although the difference was likely not the main cause of the reduced grain yield. Our results indicate that cereal rye should be terminated at corn emergence at the very latest to minimize the risk of significant corn grain yield loss, assuming that corn seedling disease and insect pressure from high biomass cover crops are not major issues and soil moisture is adequate. Otherwise, termination prior to planting is generally recommended.

9 - Effects of Rye Cover Crop, Adjuvant Use, and Residual Herbicide on *Amaranthus palmeri* Control in Soybean

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The occurrence of herbicide-resistant Palmer amaranth (AMAPA) (*Amaranthus palmeri),* along with its impact on crop yield, highlights the need for integrated weed management programs. Cereal rye cover crop (CC) biomass can suppress AMAPA establishment by up to 50%. Herbicide programs that contain residual herbicides achieve more consistent and greater control than only foliar-applied herbicides. Concerns are raised that CC biomass can intercept residual herbicides or interact with adjuvants and decrease the amount reaching the soil. The objective was to evaluate AMAPA control in soybean provided by the combination of dead (terminated 10 days before crop planting) or living (terminated at crop planting) rye CC and residual herbicide mixes with or without MSO adjuvant. An on-farm field study was conducted in 2025 near Clay Center, KS. The experiment was laid out as a split-plot design with herbicide mixes as whole plot and condition of rye CC as the sub-plot. Whole plots were 30.5 m wide by 38.1 m long, and sub-plots were 15.25 m wide by 38.1 m long with four replications. Rye CC biomass was measured before termination, AMAPA density at 21 and 35 days after planting (DAP), and AMAPA biomass production at soybean canopy (45 DAP). The farmer applied a blanket of foliar-applied herbicide after final weed assessment. Soybean was harvested with a combine and yields adjusted to 13% moisture. Rye CC biomass at termination was not different between dead (~9,330 (± 418) kg ha^{-1}) and living conditions (11,270 (± 1,167) kg ha^{-1}) (p-value=0.126). AMAPA total density (sum of 21 and 35 DAP counts) was different among condition of rye CC and herbicide mixes, where more weeds were observed in dead rye CC with no residual and in living rye CC with dimethenamid + MSO compared to living CC with flumioxazin and to dead CC with flumioxazin + MSO (p-value=0.0005). Treatments with no residual herbicide resulted in greater AMAPA biomass at the time of soybean canopy, whereas flumioxazin resulted in the least AMAPA biomass (p-value=0.0001). There was no interaction between the condition of rye CC and herbicide mixes on soybean yield (p-value=0.54). The dead condition of rye CC had a greater soybean yield (~3,600 (± 92) kg ha^{-1}) than living rye CC (~3,320 (± 96.7) kg ha^{-1}) (p-value=0.0469). An economic assessment showed no gross margin differences among combinations of condition of rye CC and herbicide mixes (p-value=0.88). These findings highlight that farmers using CC can use flumioxazin residual herbicide in their programs for achieving greater AMAPA suppression, regardless of condition of rye CC at planting and MSO inclusion. Additionally, maintaining rye CC until planting (living condition) may penalize soybean yield without being associated with a lower gross margin per hectare.

10 - Impact of Seedbank Density, Cover Crop Mulch, and Preemergence Herbicides on *Amaranthus tuberculatus* Management

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Waterhemp (*Amaranthus tuberculatus*) is one of the most challenging weeds to control in the U.S. Midwest due to its rapid growth, extended emergence period, and widespread herbicide resistance. Long-term effective weed control requires integrated management approaches. The objective of this study was to assess how varying cereal rye mulch rates and pre-emergence herbicides interact on controlling waterhemp across three seedbank densities. This greenhouse study was conducted in a completely randomized design with six replications and two experimental runs. The study consisted of a 3x8x3 factorial. The first factor was the waterhemp seedbank density, with three levels: low (40 seeds pot^{-1}), medium (250 seeds pot^{-1}) and high (1000 seeds pot^{-1}). As a second factor, 8 different amounts of cereal rye dry biomass mulch were tested: 0, 1, 2, 4, and 8 t ha^{-1}. The third factor was composed of a control treatment with no herbicide and two preemergence herbicide programs: sulfentrazone + cloransulam-methyl (173.8 + 22.4 g a.i. ha^{-1}; considered as a standard pre-emergence herbicide program) and sulfentrazone + cloransulam-methyl + pyroxasulfone (260.7 + 33.6 + 118.7 g a.i. ha^{-1}; considered as a stronger pre-emergence program). Waterhemp seeds were planted, cereal rye mulch placed on the soil surface and pots were irrigated in the day preceding application. Herbicides were applied using a research track spray chamber calibrated to deliver 140 l ha^{-1} carrier volume rate. Twenty-eight days after herbicide application, waterhemp density and biomass were collected and biomass samples were dried until constant mass before weighing. In the absence of a preemergence herbicide, higher mulch rates resulted in greater waterhemp suppression, particularly in the high seedbank scenario. The highest and most consistent level of waterhemp control was achieved with the strong program, regardless of seedbank density and mulch rate, whereas the standard program had its efficacy reduced when applied over higher mulch rates and high seedbank density. While integrating cover crops can be beneficial for waterhemp management, a strong preemergence herbicide program is still warranted, especially in highly infested areas.

11 - Understanding Weed Demographic Responses to Management Practices in the Midwest Through Density-Dependent Matrix Modeling

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Understanding long-term weed population dynamics under varying management systems is important for developing sustainable control strategies. This study utilized data from a multi-state field experiment to develop density-dependent transition matrix model that project 10-year population trends of weeds under various treatment combinations: timing of cover crop planting (site-specific: early vs. late), timing of cover crop termination (14 days prior to soybean planting), 1 day after planting [DAP] , and no cover crop), and herbicide program (burndown + POST vs. burndown + PRE + POST). Weed count data were collected at three life stages: seedlings (28 DAP), juveniles (R1), and adults (R6) to parameterize the model. Results showed a consistent decline in weed populations across all treatments over the 10-year period, with the strongest decline observed under the combined use of residual herbicide and early planted cover crops. Conversely, treatments without cover crops or residual herbicide exhibited slower population declines, driven by increased recruitment from the seedbank and survival through the life stages, suggesting a higher risk of further resistance development. The transition from seedlings to juveniles exhibited stronger density dependence compared to transitions from juveniles to adults, indicating that early life stages are more strongly regulated by intra-specific competition and management intensity. Overall, these findings demonstrate that integrating cover crop management with residual herbicide programs can significantly reduce weed population growth over time. Modeling results emphasize the importance of targeting early season emergence and seedling establishment to prevent long-term weed persistence and support the development of integrated weed management strategies that combine cultural and chemical control practices for sustainable crop production systems.

12 - Influence of Planting Date and Tillage on Diflufenican Efficacy and Crop Response

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The continued evolution of unique herbicide resistance cases in U.S. agriculture necessitates the continued development of new chemistries and the integration of complementary management strategies. Diflufenican (DFF), a carotenoid biosynthesis inhibitor (SOA Group 12) represents a novel SOA in the U.S. and is currently pending U.S. Environmental Protection Agency approval for use in corn and

soybean production for improved *Amaranthus* spp. control. The objective of the study was to evaluate how herbicide treatment (DFF alone and in combination with other active ingredients), soybean tillage system (conventional vs. no-till), and soybean planting date (early vs. late) influence DFF crop injury and weed control efficacy. The study followed a randomized complete block design with four replications. Pre-emergent herbicide treatments consisted of the same rate of DFF, as follows: 1) DFF (149 g ai ha^{-1}); 2) DFF+metribuzin (280 g ai ha^{-1}); 3) DFF+flumioxazin (15 g ai L^{-1}); 4) DFF+[flumioxazin+pyroxasulfone] (146 g ai ha^{-1}); 5) DFF+[flumioxazin+pyroxasulfone+metribuzin] (340 g ai ha^{-1}); 6) DFF+acetochlor (1569 g ai ha^{-1}); 7) DFF+metribuzin +flumioxazin (280 g ai ha^{-1} + 15 g ai L^{-1}); and 8) DFF+metribuzin+acetochlor (280 g ai ha^{-1} + 1569 g ai ha^{-1}). Data collection included percent soybean visual injury, waterhemp (*A. tuberculatus* (Moq.) Sauer) and total weed density and biomass, and soybean yield. At 7 days after emergence (DAE), soybean bleaching and overall injury were affected by herbicide program ($P<0.001$), tillage ($P<0.05$), and planting time ($P<0.05$), with a 3-way interaction among factors ($P<0.05$). The lowest bleaching (<3%) occurred in the DFF+flumioxazin+metribuzin+pyroxasulfone and DFF+flumioxazin+pyroxasulfone treatments, whereas DFF+metribuzin+acetochlor and DFF+acetochlor produced the greatest bleaching (>20%) and injury (>35-40%). Soybean bleaching and injury were highest under tilled conditions and in the later planting date. By soybean harvest, herbicide treatment ($p<0.001$) and planting time ($p<0.001$) affected total weed biomass, with DFF+flumioxazin+metribuzin+pyroxasulfone achieving the lowest weed biomass (2.5 g m^{-2}) and DFF alone the highest (22.6 g m^{-2}). Waterhemp control was ~99% across all herbicide treatments. Overall, soybean stand counts were greater under no-till (117 plants m^{-2}) than tilled soil (103 plants m^{-2}; $P<0.001$). Although some herbicide treatments had soybean injury of up to 40%, yield was only influenced by planting time ($P<0.001$) with late-planted soybeans yielding >19% higher compared to early-planted soybeans. Based on previous research, DFF-associated crop injury is thought to be associated with rainfall events and deposition from splash effect during crop stages VC to V2. Soybeans in both planting dates received adequate rainfall for herbicide incorporation. However, soybeans in the second planting date experienced consecutive rainfall events that promoted soil splashing onto cotyledons, likely resulting in higher 7 DAE bleaching injury compared to the first planting. This research provides guidance for optimizing DFF performance in relation to soybean planting date and tillage system regarding crop injury. This field study will be repeated in 2026 to validate treatment consistency and environmental interactions.

13 - Developing Computer Vision-Based Weed and Crop Mapping Technology

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Within a given crop field, crop performance and weed pressure varies spatially due to any number of biotic and abiotic factors, including management practices. Advances in computer vision and machine learning technologies have enabled mapping technologies capable of quantifying spatial variation in cash crops, cover crops, and individual weed species' growth at the sub-field scale. Such systems can provide farmers with critical insights into the effects of management practices on weed population and community

dynamics, and the subsequent impacts of weed interference on crop performance, thereby supporting data-driven management decisions.

This project, now in its fourth year, advances the development and field-scale testing of computer vision-based mapping technologies capable of quantifying spatial variation in weeds, cover crops, and cash crops growth and health. These technologies, collectively known as PlantMap3D, integrate low-cost stereo cameras (OAK-D) with cloud-based image processing pipelines to automate species identification, density estimation, and biomass mapping. Conducted through collaboration between USDA-ARS, the Precision Sustainable Agriculture (PSA) and Getting Rid Of Weeds (GROW) networks, PlantMap3D builds upon prior development of cyberinfrastructure, including open-access image repositories for five cash crop, 15 cover crop, and 44 weed species, calibration pipelines for biomass estimation, and prototype desktop and mobile interfaces for researchers and farmers.

Field calibration of the PlantMap3D began in 2022 and involves collecting images and ground-truth biomass data from cash crop and cover crop plots under a range of weed pressure levels to ensure robust model performance. Data collection included RGB and stereo imagery from fixed camera heights along representative transects, paired with sampling for biomass calibration. Collected images are automatically annotated, georeferenced, and uploaded to a cloud-based system for model training and validation. In 2025 collaborations with growers enabled the installation of prototype mapping systems on commercial sprayers to collect test imagery and verify data quality under real operational conditions.

The iterative testing and calibration of PlantMap3D are expected to yield a user-friendly, open-source mapping tool capable of identifying and quantifying weeds, cover crops, and soybeans across diverse production environments. The resulting maps will inform both short-term management actions, such as site-specific herbicide or cover crop interventions, and long-term assessments of weed population dynamics and system sustainability. Ultimately, a decision-support tool will be developed to help growers visualize how zones of weed management success and failure evolve over time, supporting more precise and resilient integrated weed management strategies.

14 - Optimizing Cover Crops, Nitrogen, and Herbicide Integration for Weed Management in Sweet Corn

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Cereal rye (*Secale cereale* L.) cover crop has proven effective in suppressing weeds but can immobilize nitrogen during decomposition, increasing the nitrogen fertilizer required for the succeeding crop. These changes in plant available nitrogen can alter weed management implications. Field experiments were conducted in Wooster, Ohio in 2025 to quantify the effect of cereal rye and hairy vetch (*Vicia villosa* Roth) cover crop, nitrogen, and preemergence herbicides on weed suppression and crop yield in sweet corn. A factorial strip-split plot design with three replications was used. The whole plot factor included cereal rye cover crop, hairy vetch cover crop, and no cover crop. The split-plot factor included 0, 112, and 224 kg nitrogen ha^{-1}. Split-split plot factor included five different herbicide programs. There was no significant interaction between any of the factors tested. Aboveground weed biomass was at least 42% lower in no cover crop treatment (3.59 g m^{-2}) than rye (6.42 g m^{-2}) or rye + vetch treatment (6.23 g m^{-2}). Weed biomass did not differ among the herbicides tested, except in dimethenamid-P plots where weed

biomass was at least 70% higher (10.07 g m^{-2}) than plots with rest of the herbicides. None of the herbicides had any effect on sweet corn yield. Rye or rye + vetch cover crops increased sweet corn yield by at least 34% compared to no crop (10.5 mt ha^{-1}). Sweet corn yield did not differ between 112 and 224 kg nitrogen ha^{-1} treatments. No nitrogen treatment had 139% lower yield (6.68 mt ha^{-1}) than 112 and 224 kg nitrogen ha^{-1} treatments. These results indicate that integrating cereal rye cover crop with moderate nitrogen input (112 kg N ha^{-1}) and a residual herbicide program can provide effective weed suppression while maintaining sweet corn crop productivity.

15 - Integrating nozzle type, row spacing and postemergence herbicide programs for Palmer amaranth control in grain sorghum

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Abstract not available.

16 - Evaluating variety, application timing, and herbicide program for annual ryegrass termination.

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Integrated pest management (IPM) strategies, such as cover crops, are one potential measure for managing weeds. Annual ryegrass (*Lolium perenne* L. ssp. multiflorum (Lam.) Husnot; also referred to as Italian ryegrass) is a cover crop species utilized in the Eastern Corn Belt due to its rapid establishment, dense root system, and ability to improve soil structure and nutrient cycling. In addition to these agronomic benefits, annual ryegrass has shown potential for weed suppression. However, termination of annual ryegrass can be challenging, as incomplete control may allow regrowth that competes with subsequent cash crops. Research has evaluated termination timing and methods across varying conditions, underscoring the need to identify effective strategies for consistent ryegrass control. A study was implemented at the Western Agricultural Research Station in South Charleston, Ohio to evaluate the termination of annual ryegrass when planted as a cover crop. The objectives of this study were to determine the effects of: 1) ryegrass variety (LowBoy, Winterhawk, Tetraprime); 2) application timing [early, 7 days preplant (7 EPP) and late, 14 days after planting (14 DAPL)], and 3) herbicide program (glyphosate + ammonium sulfate, paraquat + non-ionic surfactant) on the effectiveness of ryegrass termination. Control efficacy (0-100%) was evaluated mid-May, late-May, mid-June and mid-July to determine treatment effects of variety, application timing, and herbicide program. In mid-May, there was an interaction between ryegrass variety and herbicide program. The early termination treatments evaluation found that the Winter Hawk variety had the highest control from glyphosate at 85%, followed by Tetraprime terminated with glyphosate at 65%, which was only greater than Tetraprime terminated with paraquat at 48%. In mid-June, interactions occurred between ryegrass variety and timing and rye

variety and herbicide. The greatest control occurred where ryegrass was terminated late, and lowest where the LowBoy variety was terminated early. Winter Hawk terminated by glyphosate had the greatest control at 84%, followed by the Tetraprime with glyphosate at 58%, which were both greater than the rest of the treatments. At the final evaluation in mid-July, differences occurred between rye variety and an interaction between termination timing and herbicide. For rye variety, Winter Hawk had the highest control rating at 90%, followed by Tetraprime at 77%, and LowBoy at 52%. 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. The results of this study reveal that for Ohio, where termination of an annual ryegrass cover crop is a concern, use of the Winter Hawk variety and avoiding late termination with paraquat would be beneficial.

17 - Effects of fall- and spring-planted cover crops on kochia and Palmer amaranth suppression in dryland production systems of western Kansas

Olumide Daramola[1], Jeremie Kouame[1], Atong Akom[1], Taylor Lambert[1], Augustine Obour[1], Anita Dille[1], Johnathan Holman[1]

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Weed management in dryland cropping systems often relies heavily on herbicides, increasing selection pressure for herbicide-resistant weeds. Integrating cover crops (CCs) may reduce herbicide dependence and enhance resistance management. The effects of fall- and spring-planted CCs on weed suppression were evaluated in long-term field experiments implemented since 2020 at the Kansas State University Agricultural Research Center near Hays, KS, in no-till dryland winter wheat (*Triticum aestivum* L.) - grain sorghum [*Sorghum bicolor* (L.) Moench]- fallow (W-S-F) rotation. The field site contained a natural seedbank of glyphosate-resistant (GR) kochia [*Bassia scoparia* (L.) A. J. Scott] and Palmer amaranth (*Amaranthus palmeri* S. Watson). A randomized complete block design with four replications was established and a CC mixture of winter triticale (×*Triticosecale* Wittm. ex A. Camus [*Secale* × *Triticum*]), winter pea (*Pisum sativum* L.), canola (*Brassica napus* L.), and radish (*Raphanus sativus* L.) was planted in the fall of 2024 after wheat harvest and terminated at triticale heading prior to sorghum planting. Treatments included a nontreated control, chemical fallow, CC terminated with glyphosate (GLY), and CC terminated with GLY + acetochlor/atrazine (ACR/ATZ). Data on total emergence and weed biomass was subjected to ANOVA using R package 4.5.0, and treatment means were separated using Tukey’s HSD test at the 5% significance level. The Weibull model was also fitted to cumulative emergence (%) as a function of thermal time Total Palmer amaranth emergence under fall-planted CC systems was reduced by 77-94% compared with the nontreated control, while kochia emergence declined by 87-97% under CC + GLY and CC + GLY + PRE treatments. In the spring-planted CC systems, Palmer amaranth emergence decreased by 89-91%, and Kochia emergence by >99%, relative to the controls. At 30 days after CC termination, weed biomass was reduced by >80% in both CC + GLY and CC + GLY + PRE treatments compared with chemical fallow, and these reductions persisted through 60 days with negligible regrowth. The Weibull model fitted to cumulative emergence (%) as a function of thermal time showed that both species exhibited delayed emergence under cover-crop-based management. For Palmer amaranth, median emergence (T_{50}) occurred at 65-70 Growing Degree days (GDD) under Fall CC + RU and Fall CC + RU + PRE compared with 43-47 GDD in nontreated and fallow plots, while T_{90} required 170-180 GDD

versus 70-90 GDD in the controls. Kochia emergence was similarly delayed, with T_{50} increasing from 8-16 GDD in the nontreated and fallow plots to 17-22 GDD under CC treatments, and T_{90} extending from 40-70 GDD to 80-100 GDD. These results demonstrate that integrating fall- or spring-planted cover crops with herbicide programs substantially suppresses and delays early-season weed emergence of GR Palmer amaranth and Kochia. However, the prolonged emergence window under CC systems suggests that extended residual herbicide activity or sequential control strategies are necessary to ensure season-long weed suppression.

18 - The Space Between: Can Inter-planted soybeans improve weed management due to early-season suppression?

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[1]University of Missouri

The rapid increase in herbicide-resistant weeds threatens the long-term sustainability of weed management in U.S. soybean [*Glycine max* (L.) Merr.] production systems. Integrated weed management (IWM) strategies that enhance non-chemical control mechanisms, such as crop shading and early canopy closure, are becoming increasingly important. A field experiment was conducted in 2025 to evaluate the potential of inter-planted soybeans as an IWM practice to improve early-season weed suppression, reduce herbicide inputs, and maintain yield. Soybeans were planted at 741,000 plants ha^{-1} in either 0.19- or 0.38-m row spacings, alternating *dicamba-resistant* and *2,4-D-resistant* soybean varieties by row. Two herbicide programs were evaluated across all soybean row spacings: a pre-emergence (PRE)-only application of *S*-metolachlor (622 g ha^{-1}) + metribuzin (148 g ha^{-1}), and a PRE application of this same treatment followed by a post-emergence (PRE fb POST) application of glyphosate (127 g ha^{-1}) + glufosinate (50 g ha^{-1}). Additionally, two control groups were implemented: soybean planted at 370,000 plants ha^{-1} in 0.38- and 0.76-m row spacings with either the PRE fb POST herbicide program (standard practice) or no herbicide. At flowering (R1) or pod expansion (R4), the inter-planted 2,4-D-resistant soybeans were terminated with dicamba (226 g ha^{-1}) to create an effective row spacing equivalent to 0.38- or 0.76-m and a final population of 370,000 plants ha^{-1}. Highest soybean yields occurred in response to the 0.19-m spacing terminated at R1 to a final 0.38-m spacing with either the PRE-only (3,011 kg ha^{-1}) or PRE fb POST (3,049 kg ha^{-1}) herbicide programs. This yield level was statistically equivalent to the standard practice (2,898 kg ha^{-1}) for the same final row spacing and population. Termination of the inter-planted row at R4 led to a yield penalty. Weed densities were lowest in response to treatments where inter-planted soybean were terminated at R1 and were similar between the PRE-only and the PRE fb POST herbicide programs. These results suggest that inter-planted soybean systems, when terminated at an appropriate time, may provide opportunities to enhance canopy-driven weed suppression and potentially reduce reliance on herbicides without compromising yield.

Poster Section – Extension

19 - PEST Academy

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The Precision Education in Spray Technologies (PEST) Academy, hosted within the Precision Application Technology Laboratory (PAT Lab) at the University of Nebraska-Lincoln’s West Central Research, Extension and Education Center in North Platte, Nebraska, provides research-informed, hands-on training in modern pesticide application techniques to equip custom and private applicators, educators, crop consultants, and industry professionals with the technical knowledge and operational skills needed for optimized, sustainable, and data-driven pest management. The Academy bridges science-based learning with practical, real-world demonstrations to strengthen decision-making, ensure regulatory compliance, and enhance the long-term sustainability of crop protection programs. Its curriculum integrates spray technology fundamentals with informed decision-making to optimize herbicide efficacy, minimize off-target movement, and align management practices with the U.S. Environmental Protection Agency’s Endangered Species Act (ESA) framework. Modular training covers nozzle selection, droplet-size classification, deposition and drift assessment, label interpretation, tank-mix effects, and the role of spray additives in enhancing performance across variable environmental conditions. Interactive learning through spray tables and spray chamber demonstrations enables participants to translate research-based insights into practical field applications that improve coverage and compliance. Offered year-round in flexible formats, including half-day, full-day, and two-day sessions, the PEST Academy provides in-house and off-site training tailored to meet the needs of its audience. Participants earn Certified Crop Adviser continuing education units, a University of Nebraska-Lincoln Micro-Credential, and Nebraska Department of Agriculture recertification credits (Categories 00 and 01), with recognition in other states possible upon approval. Overall, the PEST Academy empowers agricultural professionals to make data-driven, efficient, and environmentally responsible decisions that support sustainable crop production and long-term stewardship across Nebraska and beyond.

20 - Spray Savings and Weed Control from Targeted Herbicide Applications in Corn and Soybean Fields

Guilherme Sousa Alves[1], Stephen Schwartz[2], Lance Frahm[2], Zaim Ugljic[1], Arthur F. T. Duarte[1], Rodrigo Werle[1]

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Precision application technologies are constantly evolving and are essential to optimize pesticide use and enhance profitability, especially in weed management strategies. Nevertheless, these technologies need to provide not only herbicide savings, but at least similar weed control in comparison to traditional broadcast applications. The objective of this study was to evaluate spray savings and weed control from broadcast and targeted applications in corn (*Zea mays* L.) and soybean (*Glycine max* (L.) Merrill). The experiment was conducted in a completely randomized design across six corn (76 row spacing) and 5 soybean (38 cm row spacing, XX acres minimum) fields. Within each field, treatments consisted of early post-emergence broadcast and targeted applications with three sensitivities (low - LS, medium - MS, and high - HS) for a total of four treatments. Applications were performed using a John Deere R412 See & Spray™ Premium with 36.6 m boom width and 38 cm nozzle spacing at 4.4 m s^{-1} working speed. The boom height was set at 51 cm above crop canopy. Herbicide solutions were mixed considering broadcast applications at 154 L ha^{-1} carrier volume, sprayed through TSL8004 air-inclusion flat-fan nozzles at 297 kPa pressure. At this pressure, ultra-coarse droplets were sprayed. Weed pressure and spray savings were recorded during applications. Across corn fields (V2-V5 growth stages), five ha were treated with glufosinate (878 g ai ha^{-1}) and 16 ha were treated with glyphosate (840 g ae ha^{-1}) plus tembotrione (92 g ai ha^{-1}). In soybean (V5 growth stage), 21 ha were treated with glyphosate (840 g ae ha^{-1}) plus 2,4-D choline (1,063 g ae ha^{-1}) plus clethodim (140 g ai ha^{-1}). Ammonium-sulfate (2,240 g ha^{-1}) and crop oil concentrate adjuvant (1.4 L ha^{-1}) were added to all herbicide solutions. The dominant weeds across fields were common lambsquarters (*Chenopodium album* L.) and woolly cupgrass (*Eriochloa villosa* (Thunb.) Kunth). At time of application, weeds were between 7 and 15 cm tall. At one day after application (DAA), 12 points with weeds in each treatment were randomly selected to evaluate weed control at 10 DAA, when the numbers of alive and dead weeds in a 0.6 x 0.6 m area were counted. Treatments were compared to each other using Tukey's test at 0.05 significance. Using LS and HS across corn fields, weed pressure was 4.2% and 9.1%, respectively. Although spray savings were higher using LS (49%) than HS (35%), LS provided the lowest weed mortality (37%), whereas broadcast and HS provided similar weed mortality (85%). Across soybean fields, MS and HS had similar weed pressure (from 6.4% to 7.1%) and spray savings (from 38% to 43%). The LS had the lowest weed pressure (3.1%) and the highest spray savings (57%). The broadcast and targeted applications using MS and HS resulted in 86% weed mortality, 22% points greater than LS. These findings suggest that the selection of lower sensitivities in targeted applications in order to maximize spray savings may result in reduced weed control compared to broadcast applications.

21 - Identification of Established Blackgrass (*Alopecurus myosuroides*) Population in Illinois: Prediction and Mitigation of Expansion

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Blackgrass (*Alopecurus myosuroides* Huds.) is considered one of the most problematic weeds globally due to its infestation of winter cereal acres throughout Europe, Asia, and Australia. Although the species has been documented in North America, established populations have not been noted aside from the Pacific Northwest. In 2024, an agronomic consultant from Southern Illinois inquired about an unknown grass infesting approximately 80% of a winter wheat field. Seeds attached to received plant samples were germinated and grown to maturity and used to confirm the species identification as *Alopecurus myosuroides*. This observation and confirmation of species identification makes this infestation the only known established blackgrass population in the Midwestern United States. Blackgrass is problematic in its native range due to mounting herbicide resistance, crop mimicry conducive to winter cereal crop rotation, and poorly drained soils, with adequate moisture and temperature conditions. These criteria could be used to predict habitat suitability for the invasion, establishment, and spread of blackgrass in Midwestern cereal growing regions. Therefore, the purpose of this experiment was to use publicly available geospatial data layers to predict suitable habitat for the establishment and spread of blackgrass in the Midwestern United States cereal growing regions. Raster layers of winter cereal fields (wheat, barley, rye, oats, triticale, and canola), soil drainage class, and fall crop establishment environmental conditions were created and manipulated in ArcGIS Pro 3.1.0. Habitat was considered suitable for blackgrass establishment if the field had been cropped with a winter cereal in the past 5 years, was classified as poorly drained in the USGS Soil Survey map, had temperatures ranging from 0 to 30 C, and received high rainfall during fall crop establishment. A suitability raster layer was created using the “Cell Statistics” tool to sum the weighted raster layers which were subsequently grouped into “low”, “medium”, and “high” suitability using the “Reclassify” tool. This layer was used to determine the most suitable areas for blackgrass establishment across 13 midwestern cereal growing states. The geospatial analysis indicated that suitable habitat area was greatest in Illinois, followed by Ohio, Michigan, Missouri, and Kansas for blackgrass establishment. Notably, the county where this blackgrass population was collected, Clinton County, IL, had the 6th greatest suitable habitat area. The counties with the greatest percentage of total area classified as highly suitable blackgrass habitat included Washington Co., IL > Cherokee Co., KS > Paulding Co., OH > Henry Co., OH > Putnam Co., OH > Clinton Co., IL > Wood Co., OH > Perry Co., IL > Crawford Co., KS > Huron Co., MI. These findings indicate that highly suitable areas exist for further expansion of this blackgrass population in the Midwest cereal growing regions. Mitigating the spread of this population is critical to prevent widespread establishment in these highly suitable habitats with particular emphasis on the listed high-risk counties.

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

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The use of conventional and bio-herbicides for weed control in specialty crops remains challenging due to limited guidance on optimal application parameters. Limited information on the optimal balance between droplet size (DV0.5) and driftable fines (% of droplets <141 µm), without being overly specific to individual products, can result in reduced application efficiency, crop phytotoxicity, herbicide overuse, and higher 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 and drift potential 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. All herbicides were applied at their highest labeled rates for tough-to-control weeds. For the study, six 40-degree nozzles from multiple manufacturers, DX, ER, TP, TPE, MHC, and MGH, were evaluated in a low-speed wind tunnel for droplet size distributions. All the hereby tested nozzles were operated at 276 kPa. 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, indicating a reduction in spray drift potential. As anticipated, the hollow-cone nozzles MHC and MGH 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 hollow-cone 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, cinnamon oil, and d-limonene consistently exhibited driftable fines below 9% across all nozzle types compared with water, indicating a consistent drift-reduction potential across the tested combinations. These findings provide a foundation for developing practical recommendations to help growers select appropriate nozzle-by-solution combinations, improving application efficiency, minimizing off-target movement, and reducing the risk of crop injury and herbicide overuse in specialty crop production systems.

Poster Section – Equipment and Application Technologies

23 - Cereal Rye Cover Crop Biomass Guide: A Practical Resource for Practitioners

Guilherme Chudzik[1], Eric Yu[2], Bailey Tangen[2], Jose Nunes[3], Karla Gage[4], Sarah Lancaster[5], Travis Legleiter[6], Joe Ikley[7], Jason Norsworthy[8], Bryan Young[9], William Johnson[9], Kevin Bradley[10], Alyssa Essman[11], Christy Sprague[12], Vipin Kumar[13], Ryan DeWerff[1], Rodrigo Werle[1]

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Cereal rye (*Secale cereale* L.) is widely adopted as a cover crop species due to its winter hardiness and rapid and high spring biomass production, making it a suitable conservation crop across the US corn-soybean producing regions. As growers adopt cereal rye as part of their integrated weed management programs, the main factor determining whether weed suppression is achieved is the amount of biomass produced by the cover crop. Researchers apply labor-intensive methods to quantify the amount of dry biomass produced by cover crops in their research. Farmers and crop advisors lack the time and resources to quantify cereal rye biomass to support their management decisions. Therefore, after intensive multi-year-site data collection, this effort provides a practitioners' practical guide for estimating cereal rye dry biomass using plant height. Cereal rye dry biomass and height were highly correlated $R^2 = 0.78$. Cereal rye height of 7, 12, 24, and 32 inches (18, 30, 61, and 81 cm) corresponded to 350, 970, 2,450, and 5,100 lb ac^{-1} (390, 1,090, 2,750, and 5,720 kg ha^{-1}) of cereal rye dry biomass. Information generated by researchers is extremely valuable for the scientific literature and community as a whole, however, efforts to make scientific information more practical and readily available for growers and their decision influencers are as equally important, so that we can benefit both the scientific community and agricultural practitioners.

24 - Efficacy of robotic mechanical weed control in Michigan cabbage

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The profitable production of vegetable crops, including cabbage, is increasingly threatened by herbicide resistant weeds, weather-induced herbicide failures, and rising labor costs associated with hand weeding. Autonomous mechanical cultivation can provide a new potential control mechanism for cabbage growers.

Field trials were conducted in Holt, MI to evaluate the efficacy of autonomous mechanical weeding with varying levels of herbicide treatment on in-season weed populations and cabbage yield. Three intensities of cultivation (none, low, and high) were tested with four levels of herbicide (none, preemergence (PRE), postemergence (POST), and PRE + POST). Autonomous mechanical weeding was accomplished with the Naio ‘Oz’ compact robot, equipped with sweeps, cutaway disks, finger weeders and tines. Trials were conducted during the growing season of 2024 and 2025. Autonomous cultivation was found to significantly increase yield and reduce weed density in both years, with a significant interaction between herbicide level and cultivation in 2025. Integration of autonomous mechanical control may increase yield by reducing weed interference, particularly when herbicide failure is present in the field. Further, autonomous mechanical cultivation can significantly reduce end of season weed escapes in the field.

25 - Spray Water Quality: An Overlooked Factor in Herbicide Performance

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Water commonly comprises more than 95% of spray solution volume, and its chemical characteristics can strongly influence herbicide performance. High concentrations of cations such as Ca^{2+}, Mg^{2+}, and Fe^{3+} may interact with herbicides including glyphosate, reducing biological activity. Likewise, water pH can affect herbicide stability, particularly for weak-acid chemistries, potentially altering degradation rate and treatment efficacy. Strategies such as field assessment of water characteristics and use of pH conditioners or buffering agents may help mitigate water-quality-related antagonism. Field experiments were conducted in 2025 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 treatment (DAT). Waterhemp density and biomass were determined at 112 DAT using a 0.5 m × 0.5 m quadrat placed randomly between the center crop rows within each plot. Waterhemp response did not differ between POST application rates, and the timing of the pH-adjusting adjuvant (6 d before vs. day-of application) did not influence any measured variable. In contrast, the presence of the pH adjuster improved outcomes regardless of application timing. At 24 DAT, waterhemp control increased by 10% when the pH adjuster was used. By 112 DAT, control remained improved by 7% compared with treatments without the pH adjuster. Waterhemp density declined 64% with the pH adjuster, and aboveground waterhemp dry biomass was reduced by 55%. These results demonstrate that adjusting alkaline spray water with a pH-lowering adjuvant significantly improves waterhemp management, providing measurable gains in mid- and late-season control and substantial reductions in density and biomass.

26 - Impact of nozzle type and imazamox mixtures with auxin herbicides on droplet characteristics and canopy penetration

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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. In this context, nozzle selection is crucial for ensuring adequate herbicide deposition and canopy penetration while minimizing off-target movement. Field experiments were conducted during the summer of 2025 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 programs on canopy penetration, spray deposition, and Palmer amaranth and kochia control 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 and dual-fan) 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. The herbicides were applied using a CO_2 backpack sprayer calibrated to deliver 140 L ha^{-1} at 276 kPa using either an AIXR or an AITTJ60 11002 nozzles. The cards were digitally scanned using DepositScan software to determine percent coverage and droplet densities. Spray deposition results showed row spacing-by-herbicide interaction ($p < 0.0001$), nozzle type ($p = 0.0013$), and card position ($p = 0.0011$) effects. Across locations, row spacing, herbicide program, and card position showed that the number of deposits was more for the AIXR than the AITTJ60 nozzles. Also, across locations, row spacing, herbicide program, and nozzle type, the above-canopy card showed considerably more deposits than the below-canopy card. But in general, the AITTJ60 nozzles increased the number of deposits at the below-canopy card compared to the AIXR nozzles, particularly in the narrower-row spacing. Complementary laboratory research showed that the 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 greatest droplet size, thereby 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.

27 - Reverse Osmosis Water: Can It Aid Herbicide Efficacy

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Many factors influence the success of herbicide applications. Water is typically utilized as the carrier, and its quality can be a contributor or deterrent to the effectiveness of an application. Water quality is

measured by the presence of dissolved calcium and magnesium and is referred to as “hardness”. Ground water (well water) is a common source for applications in the US and can be very hard depending on location. The addition of ammonium sulfate (AMS) to the spray solution is common to overcome this influence, and applicators in areas of very hard water sources also utilize reverse osmosis (RO) to improve herbicide application efficacy. A greenhouse study was conducted to examine measures utilized to mitigate inferior water quality. Glyphosate (Group 9), dicamba (Group 4), fomesafen (Group 14), and rimsulfuron + thifensulfuron (Group 2) were evaluated to represent a range of herbicide sites of action utilized in postemerge row crop weed management. Each herbicide was applied with four water quality treatments: well water, RO water, well water + AMS and RO water + AMS. Weed species Palmer amaranth (*Amaranthus palmeri*) , common lambsquarter (*Chenopodium album*), kochia (*Bassia scoparia*), velvetleaf (*Abutilon theophrasti*) and green foxtail (*Setaria viridis*) were evaluated. Treatments were applied with an AIXR11004 nozzle at 140 l ha^{-1} carrier volume. Plants were visually rated for percent control and dry biomass reduction calculated 28 days after application. Where differences existed among water source or addition of AMS, trends differed among the species. The use of RO or AMS increased control in some species, but not in all scenarios. AMS or RO water was also not detrimental.

28 - Impact of Water Type (Hard Water vs. Reverse Osmosis) on 2,4-D and Glufosinate-L Spray Deposition and Weed Efficacy

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Effective weed management depends on several factors influencing pesticide application performance, including the quality of the carrier water used in spray solutions. The composition of water sources can alter the behavior of spray mixtures and the overall biological performance of herbicides on target weeds. This study evaluated the influence of two water sources, hard tap water and reverse osmosis water, on herbicide efficacy when used with and without ammonium sulfate (AMS) water conditioning agent (20 g L^{-1}). Two herbicide active ingredients, L-glufosinate-ammonium (Glu-L, 370 g ai ha-1) and 2,4-D choline (1065 g a.e. ha^{-1}), were applied individually and in a tank mix to assess efficacy on *Abutilon theophrasti Medik.* and *Chenopodium album L.* when plants reached 10-15 cm in height. All spray solutions contained methylated seed oil (1.17 L ha^{-1}). In addition to efficacy, deposition was assessed using artificial collectors consisting of kromekote cards, treated with a food-grade blue dye (1.5 g L^{-1}) added to each spray solution to enable visual quantification of spray coverage across treatments. Applications were conducted in a spray chamber calibrated to deliver 140 L ha^{-1} using a 38.1 cm nozzle spacing at 276 kPa, employing AIXR11004 (AIXR) and AITTJ11004 (AITTJ) nozzles to compare potential interactions between spray quality and water source characteristics. Visual symptoms were evaluated up to 21 days after application. After the final rating, the weeds were harvested and dried until the plants reached a constant dry biomass. For both species tested here, no differences were observed in the control between applications of 2,4-D choline salt alone or in a tank mix with Glu-L. For A. theophrasti, hard water reduced efficacy with the AIXR nozzle, while the dual-fan AITTJ improved performance. For C. album, AITTJ generally provided greater control, with AMS improving results only under hard-water conditions and offering no added benefit with reverse-osmosis water. Across nozzle types, AIXR produced greater deposition on the top of the plant collector than AITTJ across all water sources and solutions. No

differences in deposition were observed across water types except for the Glu-L solution, where coverage increased under reverse osmosis water compared to hard water. The addition of AMS did not affect deposition within either water type; however, reverse osmosis water generally resulted in greater overall coverage. These findings show that water quality and application setup are important for consistent Glu-L performance. Control was not different for 2,4-D alone or when tank-mixed with Glu-L, but nozzle type and water conditioning influenced weed response for Glu-L, especially under hard water conditions. Further research is needed to understand why the AIXR nozzle produced lower control despite greater coverage, emphasizing the need to explore multi-directional deposition on targets and its role in herbicide efficacy.

29 - Evaluation of HM2113 Adjuvant in Glufosinate Weed Control Program

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Glufosinate (Ignite, Liberty, Liberty Ultra) weed control programs first began with the introduction of trait technology in 1995 in corn (*Zea maize*), canola (*Brassica campestris*) and cotton (*Gossypium hirsutum)* in 2004, and soybean (*Glycine max*) in 2009 by Bayer Corporation. BASF acquired the technology in 2015. The evolution of glufosinate-based weed control programs reflects a broader trend toward integrated herbicide technologies that optimize efficacy through synergistic additives. The requirement for ammonium sulfate (AMS) in glufosinate applications underscores its critical role in improving herbicide performance by mitigating hard water antagonism and enhancing foliar absorption. AMS facilitates electron transport and hydrogen ion exchange, which accelerates uptake and amplifies the herbicidal effect of glufosinate by promoting rapid ammonia accumulation within plant tissues.

However, AMS use introduces logistical challenges, including handling large granular volumes and ensuring uniform mixing. The development of HM2113 addresses these limitations by combining AMS with complementary components—such as AMADS (aminomethanamide dihydrogen tetraoxosulfate) for enhanced hydrogen ion pump activity, buffering agents for optimal pH, and humectants for improved leaf surface retention—into a liquid formulation. This innovation not only simplifies application but also maintains or improves weed control efficacy compared to traditional AMS rates.

Over three years of replicated field trials across multiple states in the North Central United States demonstrate that HM2113 at 2.35 L/Ha (1 qt/Ac) statistically performs the same as or better than AMS at 2.25 kg/Ha (2 lbs/Ac) across diverse weed species, and even matches the performance of higher AMS rates 3.48 kg/Ha (3 lbs/Ac) under most conditions. These results suggest that HM2113 can reduce handling complexity without sacrificing control, offering agronomic and operational advantages. Furthermore, the findings highlight the importance of formulation science in herbicide systems, where uptake dynamics, environmental conditions, and synergistic chemistry collectively determine field performance.

Future research should explore HM2113's adaptability across more varying climatic zones, its interaction with other herbicide programs, and potential contributions to resistance management strategies. By advancing beyond traditional AMS reliance, HM2113 represents a significant step toward more efficient, user-friendly, and environmentally conscious weed control solutions.

30 - Using Drone Imagery to Assess Herbicide Application Success and Guide Respray Decisions

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Efficient herbicide management depends on rapid, spatially precise assessment of application success. Traditional visual scouting is time-consuming, subjective and often occurs past the optimal respray window. Unmanned aerial vehicles (UAVs) provide an objective, near-real-time approach for evaluating weed responses following herbicide applications. A field experiment was conducted in Lafayette, IN, to utilize high-resolution drone imagery to accurately assess herbicide efficacy and guide respray decisions for soybean [*Glycine max* (L.) Merr] production. The experiment was organized as a randomized complete block 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 species. A DJI Mavic 3M was flown at 21 m to capture multispectral and red-green-blue (RGB) imagery 1, 3, 5, and 9 days after application (DAA). Imagery was processed in Pix4Dfields to generate vegetative indices: Green Normalized Difference Vegetation Index (GNDVI), Normalized Difference Vegetation Index (NDVI), Leaf Chlorophyll Index (LCI), and Visible Atmospherically Resistant Index (VARI). Data were analyzed using a mixed-model ANOVA to evaluate herbicide and timing effects and Pearson correlations were used to assess relationships among ground-truth weed control, weed mortality (5 plants plot^{-1}), and vegetative indices. Herbicide and timing interaction were significant ($p<0.001$). GNDVI, NDVI, and VARI were strongly and negatively correlated (r = -0.74 to -0.90) with visual volunteer corn control at 3 DAA for contact herbicides (paraquat, fomesafen, and glufosinate-ammonium), allowing early identification of respray zones before visual confirmation. Systemic herbicides (2,4-D and glyphosate) showed negative correlations ($r = -0.71$) with giant ragweed control at 5 DAA, indicating delayed spectral responses. At 3 DAA, GNDVI, NDVI, and VARI were negatively correlated ($r = -0.55$) with corn mortality and positively correlated ($r = 0.45$) with ragweed mortality for contact herbicides, meaning these indices decreased as corn mortality increased and increased as ragweed control improved. These results demonstrate that UAV-based spectral indices can detect herbicide treatment failures as early as 3 DAA for contact herbicides and 5 DAA for systemic herbicides. Species-specific responses also influence detection accuracy. Integrating UAV imagery with vegetative indices enables timely, site-specific resprays, enhancing weed control efficiency, reducing input costs, maintaining environmental stewardship, and protecting crop yield.

31 - Spray Particle Drift from Targeted and Broadcast Herbicide Applications

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New application technologies have been developed and spray particle drift needs to be assessed under field conditions. Two methods of targeted herbicide applications, without and with variable rate (VR), have taken place in integrated weed management. Targeted applications without VR do not apply any rate when weeds are not detected. Conversely, in targeted applications with VR, a partial the rate is constantly applied broadcast when weeds are not detected, and the total rate is applied only when the system detects weeds. This study aimed to compare the spray drift from two targeted application methods with broadcast applications. Research was conducted in a 3 x 7 split plot scheme arranged in a randomized complete block design with eight replications. Main plots and subplots consisted of three application methods [broadcast, targeted without VR, and targeted with VR (50% rate applied broadcast and 50% upon weed detection)] and seven downwind distances (1, 2, 3, 4, 8, 16, and 32 m), respectively. A John Deere R412 See & Spray™ Premium with 36.6 m boom width and 38 cm nozzle spacing was used to spray water plus tracer at 5.0 m s^{-1} travel speed to deliver a total of 187 L ha^{-1}. Boom height was set at 74 cm above ground. Applications were performed on wheat stubble (10 cm tall). In broadcast and targeted applications without VR, and targeted application with VR, TP 8005 and TP 8003 nozzles were used at pressures of 338 kPa and 235 kPa, respectively, which produce medium droplets. As tracer, PTSA (pyrene tetrasulfonic acid) was added to the spray solution at 2 g L^{-1}. During applications, average wind speed was 1.8 m s^{-1} and predominant wind direction was 110 degrees. Perpendicular to the wind direction, applications were performed on a 100-m length by 36.6-m width area. Parallel to the wind direction, five transects 7 m apart with seven distances each were positioned downwind from the edge of treated area. Mylar cards (10 x 10 cm) were placed horizontally at wheat stubble height. After application, drift collectors were placed into plastic bags to be processed in laboratory. Third milliliters of 91% isopropyl alcohol:distilled water (10:90 v v^{-1}) were added to each bag and an aliquot was quantified by fluorometer. Using tracer calibration curve, data were converted into percentage of applied rate (AR) and treatments were compared to each other within distance using Tukey’s test at 0.05 significance. Savings from targeted applications without VR was 85% and with VR was 42%. Regardless of distance, targeted applications without VR and with VR reduced spray drift by 84% and 44%, respectively, in comparison to broadcast applications. From 1 to 4 m, broadcast applications resulted in the greatest spray drift (2.35% to 7.74% AR). At 16 m and beyond, no differences were observed across methods and up to 0.15% AR was detected at 32 m. These results suggest that targeted herbicide applications may reduce environmental contamination risks. Additional research should be conducted to evaluate spray drift from other droplet sizes, solution types, and weather conditions.

32 - Dose-Response of Palmer amaranth (*Amaranthus palmeri* S. Watson) to Glufosinate-L with and without AMS and MSO Using AIXR and TTJ Nozzles

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Recent regulations issued by the U.S. Environmental Protection Agency under the Endangered Species Act have brought modifications to the herbicide registration and review process. The new policy requires applicators, as defined by the product label, to implement mandatory mitigation measures when using

newly registered or re-registered products. L-glufosinate-ammonium (Glu-L) was registered following the policy update. According to the product label, the use of oil-based adjuvants with drift-reducing properties may allow for the removal and/or reduction of mandatory buffer zones during ground applications. Previously, it has been shown that the addition of methylated seed oil (MSO) can reduce off-target movement (OTM) under certain conditions and may also enhance herbicide efficacy. However, its influence when combined with Glu-L remains uncertain, warranting further investigation to evaluate potential benefits beyond OTM reduction. Therefore, this study aimed to assess the addition of adjuvants to Glu-L *Amaranthus palmeri* S. Watson control. A randomized complete block design was used with five replications. The treatments consisted of Glu-L, alone and in combination with ammonium-sulfate (AMS, 2200 g ha^{-1}), MSO (1.17 L ha^{-1}), and AMS + MSO, which were sprayed using the AIXR and TTJ60 nozzles. Glu-L was applied in the following doses 11.6, 46.2, 92.5, 185, 370, and 1110 g a.i. ha^{-1}, while AMS and MSO had a constant rate for all treatments evaluated. The application was completed when plants reached a height of 7.6 to 12.7 cm, in a spray chamber calibrated to deliver 140 L ha^{-1} at 276 kPa with nozzles spaced 76.2 cm apart. Visual evaluations were conducted up to 21 days after application (DAA). Biomass was collected at 21 DAA and weighed after drying until a constant weight was achieved. Observations suggest that adjuvant integration with Glu-L may influence the biological response; however, confirmation requires a comprehensive dose-response evaluation. The outcomes of this study are expected to provide insight into whether the addition of adjuvant(s) offers practical benefits beyond OTM mitigation, contributing to more informed application recommendations for glufosinate-based weed management systems.

33 - Spray Deposition from Targeted Herbicide Applications Through Different Nozzle Types

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Satisfactory weed control is highly dependent on the correct product amount reaching the target. It is known that application technology methods may deliver inconsistent amount of products and this subject needs to be investigated mainly in precision techniques. The objective of this study was to evaluate the effect of nozzle type and boom height on spray deposition from targeted herbicide applications. The research was conducted at the Arlington Research Station of the University of Wisconsin during the 2025 growing season in a 3 x 2 + 1 factorial scheme arranged in a Randomized Complete Block Design with four replications and two experimental runs. For targeted applications, factors were three nozzle types (TSL 6005, TSL 8005, and ULD 12005) and two boom heights (51 and 76 cm). An additional treatment consisting of broadcast applications through TSL 8005 nozzles at 51 cm boom height was also evaluated. A John Deere R412 See & Spray™ Premium with 36.6 m boom width and 38 cm nozzle spacing was used to spray water plus fluorescent tracer at 140 L ha^{-1}, 5.3 m s^{-1} travel speed, and 226 kPa pressure. At this pressure, ultra-coarse droplets were sprayed. As tracer, PTSA (pyrene tetrasulfonic acid) was added to the spray solution at 1 g L^{-1}. Applications were performed under adequate wind speeds (from 0.8 to 1.7 m s^{-1}) on wheat stubble (10 cm tall) in a field with very low weed pressure. For this reason, corn (*Zea mays* L.) plants at V4 growth stage (15 cm tall) were used to trigger the targeted system at medium sensitivity.

Each replication corresponded to a 25 m pass where 10 plants were randomly distributed across the sprayer boom width. Petri dishes (85 mm diameter) were positioned alongside the corn plants at target height. After applications, Petri dishes were collected and placed in a dark container until being processed in laboratory. Ten milliliters of 91% isopropyl alcohol:distilled water (10:90 v v^{-1}) were added to each Petri dish and a sample aliquot was quantified by fluorometer. Using the tracer calibration curve, data were converted into percentage of applied rate (AR) in relation to available rate in the tank and treatments were compared to each other using Tukey's test at 0.05 significance. No interaction was observed between nozzle type and boom height in spray deposition from targeted applications. The TSL 6005, TSL 8005, and ULD 12005 nozzles provided similar deposition on target, which ranged from 73% to 77% AR. Boom height did not affect deposition on target regardless of flat-fan angle. Moreover, all targeted applications delivered equivalent deposition on target as broadcast applications (77%). The coefficient of variation for percentage of AR was similar across treatments and ranged from 10% to 13%. These findings indicate that once weeds are detected, both targeted and broadcast applications may spray similar product rates on targets. However, future research should be conducted to evaluate if that trend would occur in applications with other spray methods, droplet sizes, and faster wind speed conditions.

34 - Can Historical Weed Density Maps Guide Variable-Rate Residual Herbicide Applications in Soybean?

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Spatial variability in weed populations often leads to inefficient herbicide use when uniform rates are applied across entire fields. Site-specific applications may optimize residual herbicide placement by aligning application rate with weed seedbank density. On-farm field experiments were conducted in Salina, Kansas, in 2025 across three fields to evaluate whether historical weed density maps can guide variable-rate residual herbicide applications in soybean (*Glycine max* L.) production. Two treatments were included: broadcast at a standard herbicide rate and variable-rate application according to weed density. Treatments were assigned to strips that aligned with sprayer passes and replicated three to four times in each field. Polygons were delineated around areas of high weed density based on maps generated from targeted herbicide applications during the prior season. Within each strip, six 4 x 4 m squares were selected, three inside of polygons with high density and three outside representing low density areas. Two application rates were tested**:** 140L ha^{-1} (high rate, applied to high-density polygons) and 123 L ha^{-1} (standard rate, applied to low-density polygons**)**. Treatments were applied as PRE-emergence applications of sulfentrazone (0.28 and 0.25 kg a.i ha^{-1}) and acetochlor (1.68 and 1.47 kg a.i ha^{-1}) using the John Deere See & Spray™ Ultimate equipped with ExactApply™ MultiRate, which allows 11 different application rates across the boom. Weed control and crop injury were visually assessed 3 and 7 weeks after treatment (WAT). Data were analyzed using ANOVA and Tukey's HSD. Weed control and soybean injury were similar for both treatments at both evaluation times. Weed control was greater than 95% in all cases, except for one high-rate polygon with 90% control 3 WAT. Crop injury was less than 15% across all sites and treatments. These results suggest that increasing residual herbicide rates in areas with greater weed density will not improve weed control because standard residual herbicide rates were sufficient to maintain early-season weed control and acceptable crop injury. Incorporating historical weed density maps into prescription herbicide programs may improve input efficiency; however, continued multi-year research across diverse environments is necessary to validate the approach of variable-rate residual herbicide application and confirm long-term benefits in soybean production systems.

35 - Effect of Nozzle Orientation and Boom Height on Spray Coverage and Weed Control in Targeted Herbicide Application Systems

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Recent advancements in sprayer technology have led to the development of targeted herbicide application systems capable of real-time, green-on-green weed detection and treatment. These systems combine camera-based sensing and machine learning to distinguish weeds from crops and activate specific nozzles for precise herbicide delivery. Although targeted spraying offers a more precise alternative to traditional broadcast applications, manufacturers vary in their nozzle activation strategies. The effects of nozzle type, number of activated nozzles, and nozzle orientation on spray deposition and weed control remain uncertain. Nozzle orientation plays a critical role in targeted application systems because it determines when and where the spray is released after a weed is detected, potentially affecting spray solution placement on the target. The objectives of this research were to evaluate the effects of nozzle orientation and boom height on spray coverage and weed control. Field experiments were conducted in 2025 at O'Brien Farm near Brooklyn, Wisconsin, while a complementary controlled-environment study investigating spray coverage with and without presence of wind was conducted at the UW-Madison Agricultural Research Station in Arlington, Wisconsin. The field study followed a two (53cm - ideal boom height vs 76 cm boom heigh) × two (conventional 90° straight down vs 30° rearward inclined nozzle orientation) factorial design plus a nontreated control weedy check. The controlled-environment study followed the same factorial arrangement as the field study, with the addition of wind as a factor (no wind vs. presence of wind [10 km/h]). Applications were made using a CO_2-pressurized, three-nozzle boom (nozzles spaced 38 cm apart and calibrated to deliver 140 L ha^{-1}) mounted on a bicycle wheel and equipped with flat-fan (TeeJet DG80015) nozzles. In the field study, glufosinate (656 g ai ha^{-1}) was applied POST to ~10 cm tall *Amaranthus tuberculatus*. Biomass samples were collected 14 days after treatment (DAT) from three subsamples per plot. Spray coverage in water sensitive cards (7.6 x 5 cm) was evaluated in the controlled environment study. Applications in the field experiment were conducted under low-wind conditions (~2 km/h), likely explaining lack of differences observed in waterhemp weed control (>97%) and biomass reduction (99%) across treatments 14 DAT. In the controlled environment study, the ideal boom height (53 cm) provided the greatest spray coverage (45%) in no wind conditions, however boom at 76 cm provided the lowest (14%) spray coverage in presence of wind. Both nozzle orientations produced similar coverage (≥42%) in no wind conditions and ideal boom height, whereas the 30° rearward inclined orientation resulted in the lowest coverage (16%) under presence of wind and boom at 76cm. Across treatments, wind reduced spray coverage from 43% (no wind and ideal boom height) to 16% (in presence of wind and boom at 76 cm). These findings highlight the potential risk of targeted spray coverage reduction, particularly when operating with higher boom heights and rearward nozzle

orientations under windy conditions. Therefore, further research is warranted to better understand these interactions across a broader range of environmental and operational conditions to support best practices for targeted applications.

36 - Effect of Herbicide, Spray Nozzle Type, and Carrier Volume on Waterhemp Control in Corn and Soybean

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Waterhemp (*Amaranthus tuberculatus*) is one of the most troublesome weed species in corn (*Zea mays*) and soybean (*Glycine max*) production systems in Iowa. Its prolific seed production, rapid growth, and widespread herbicide resistance make management highly challenging for growers across the state. Therefore, selecting not only the appropriate herbicide but also the most effective application parameters is essential to achieve satisfactory control. This study aimed to evaluate the effects of herbicide, spray nozzle type, and carrier volume on waterhemp control in corn and soybean fields. Field experiments were conducted at the Curtiss Farm in Ames, IA, in 2025. Treatments were arranged in a three-factor factorial design with four replications. In corn, the factors included two herbicide treatments (S-metolachlor + glyphosate + mesotrione + bicyclopyrone and dicamba + glyphosate), two nozzle types (TT and TTI), and two carrier volumes (94 and 140 L ha^{-1}). In soybean, factors consisted of three herbicide treatments (glyphosate + fomesafen, glufosinate, and 2,4-D + glyphosate) and the same two nozzle types and carrier volumes as in corn. Applications were made using a three-nozzle handheld CO_2-pressurized backpack sprayer. Waterhemp control was visually assessed 28 days after application relative to the untreated control. Data were analyzed in SAS using the PROC GLIMMIX procedure, and means were separated using Tukey's test at $\alpha = 0.05$. In corn, waterhemp control was similar across all herbicides, nozzle types, and carrier volumes. In soybean, nozzle type did not affect control, but the herbicide by carrier volume interaction was significant. While 2,4-D + glyphosate provided greater waterhemp control at 140 L ha^{-1} than at 94 L ha^{-1}, glyphosate + fomesafen and glufosinate treatments had higher control at 94 L ha^{-1} compared to 140 L ha^{-1}. Findings of this study suggest that the influence of carrier volume is herbicide-specific, and that droplet size did not impact control for the herbicides and carrier volumes evaluated.

37 - Crop Injury from Postemergence Applications of the Encapsulated Saflufenacil + Pyroxasulfone Premixture is Influenced by Application Time of Day

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An encapsulated formulation of saflufenacil was recently developed and commercialized for weed management in corn. The encapsulation serves as a barrier to foliar absorption, which allows for early postemergence applications with little risk of crop injury. However, foliar applications of encapsulated saflufenacil may cause low levels of temporary crop injury, which can be enhanced by tank mixtures including oil-based activator adjuvants and foliar-active herbicides. Previous research with saflufenacil and other light-activated herbicides has reported application time-of-day and light-intensity effects for weed control and crop injury. A controlled environment experiment was conducted to evaluate the effects of time of day and light intensity after application on corn injury from postemergence applications of the encapsulated saflufenacil + pyroxasulfone premixture. Corn was grown to the V2 growth stage in a controlled environment chamber set to a 16-h light, 8-h dark cycle. On the day of application, the chamber was divided into two light regimes: high light intensity (750 µmol m^{-2} s^{-1}) and low light intensity (100 µmol m^{-2} s^{-1}). Plants were treated with a field rate of encapsulated saflufenacil + pyroxasulfone (200 g ai ha^{-1}) + crop oil concentrate (1% v/v) + ammonium sulfate (5% v/v) at sunrise, solar noon, or sunset based on the growth chamber light cycle. Corn injury 3 days after application (DAA) ranged from 1 to 7% and was greatest from the sunrise application. Similarly, the sunrise application reduced green V3 leaf tissue by 5%. At 7 DAA, the same application time-of-day effect was observed, but injury across all application times was less than 5%. Based on these results, applicators should carefully manage postemergence application parameters, including application time, when applying encapsulated saflufenacil postemergence to minimize the extent of crop response. However, all corn injury from the encapsulated saflufenacil formulation would be considered minor and well within commercial norms.

38 - System Sensitivity, Nozzle Type, and Boom Height Effects on Targeted Herbicide Application Outcomes

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The effectiveness of any application technology depends on various controlled and uncontrolled factors. This study aimed to evaluate how some controlled operational factors affect hit rates and spray savings in targeted herbicide applications. The experiment was conducted in a 3 x 2 x 2 factorial scheme arranged in a randomized complete block design with three replications. Factors were three nozzle types (TSL 6005, TSL 8005, and ULD 12005), two boom heights (51 and 76 cm) above crop canopy, and two system sensitivities (medium - MS and high - HS). A John Deere R412 See & Spray™ Premium with 36.6 m boom width and 38 cm nozzle spacing was used to spray water alone at 5.3 m s^{-1} travel speed and 226 kPa pressure, which delivered 140 L ha^{-1}. Applications were performed on corn (*Zea mays* L.) and soybean (*Glycine max* (L.) Merrill) at V4-V5 growth stages cultivated at 76 cm row spacing in flat fields of Wisconsin. Each replication corresponded to a 300 m pass where 20 points were randomly distributed across the sprayer boom. Ten points with weeds between 4 and 8 cm (either length, width, or height) and 10 points without weeds in a 1.5 m radius were used to assess rates of true positive and false positive. A water sensitive card (3 x 3 cm) was placed at each point to evaluate the presence or absence of droplets after application. Weed pressure and spray savings were also recorded. Treatments were compared to each other using Tukey’s test at 0.05 significance. No interaction between factors was observed. Either in corn or soybean, weed pressure and true positive rates were not affected by nozzle type and boom height. Weed pressure ranged from 2.6% to 2.8% in corn and 2.3% to 2.5% in soybean. On average, the true positive rates were 86% in corn and 88% in soybean. The ULD 12005 nozzle resulted in the greatest false positive rates (29% in corn and 28% in soybean) and the lowest spray savings (34% in corn and 38% in

soybean) compared to the other nozzles. In corn, the TSL 6005 produced greater spray savings (51%) than TSL 8005 (44%) and applications at 76 cm boom height reduced the spray savings by four percent points. In soybean, no difference in spray savings was observed between nozzle types and boom heights. The HS improved true positive rates by 10% and 17% points in corn (91%) and soybean (96%), respectively, compared to MS. However, spray savings were reduced by 12% points in corn (47%) and 14% points in soybean (52%) using HS in relation to MS. Therefore, nozzle type and system sensitivity were the most important factors that affected hit rates and spray savings. The 60 and 80 degree flat-fan angles increased spray savings without compromising hit rates on weeds. In fields where small weeds are the target, applications with HS along with lower boom height should be used to mitigate weed escapes and potentially weed resistance in the future.

39 - Droplet Size, Drift Risk, and Deposition Patterns of Selected Coarse and Very Coarse Nozzles

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For all post-emergence herbicide applications, ensuring adequate coverage is vital for effective weed control. Reducing drift risk while maximizing spray deposition across all growing points of the plant is closely linked to nozzle selection and spraying configuration. For coarse and very coarse droplets, the risk of drift decreases as droplet size increases; however, spray coverage on the weed canopy, particularly across upper leaf surfaces and along growing points on stems, may be reduced. The objectives of this study were to evaluate the effect of selected coarse and very coarse nozzles (AIXR, TT, TTJ60, and AITTJ) on droplet size and multidirectional spray coverage. Nozzles were first tested in a low-speed wind tunnel (6.71 m s^{-1}) with water only at 276 kPa for droplet size classification. For spray deposition assessment, the same nozzles were evaluated in a spray chamber, with TT nozzles positioned both uniformly (u) and alternate (a). Two nozzle spacings (0.38 m and 0.76 m; a spacing-to-height ratio of 1:1) were tested with water and the addition of a 1.5 g L^{-1} dye solution calibrated to 140 L ha^{-1}. Data were collected using artificial collectors with kromekote paper (19.4 cm^2) in five different positions (top, 0º, 90º, 180º, and 270º, degrees relative to spraying direction) to simulate a plant canopy. Droplet size increased and drift potential decreased from TT to AIXR, AITTJ, and TTJ60 nozzles, indicating improved drift control with coarser sprays. Coverage was consistent across nozzle spacings for all nozzles except AIXR, which showed a difference. Multidirectional spray deposition findings indicate that spray deposition varied among nozzle types and directions. Across directions, AITTJ and AIXR generally produced greater deposition at 0° than other nozzles, while TT(u) resulted in the lowest values. Within each nozzle, deposition was typically greater at 0° and decreased toward 180°, indicating reduced backward deposition. TT(a) showed the most balanced distribution across directions, whereas AIXR and AITTJ demonstrated more pronounced directional differences. While coarse and very coarse droplets reduce drift, they may limit deposition in lower canopy areas and along stems. Greenhouse efficacy testing (across different plant architectures) is needed to validate benefits to weed control, followed by field evaluation to assess interactions with crop canopy and product performance.

40 - Evaluation of late-season weed control in soybean using unmanned aerial vehicles (UAV) and ground sprayers in dryland production systems of western Kansas

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The adoption of spray drones for herbicide application is expanding rapidly across agricultural systems. Yet, limited technical information exists regarding optimal operational parameters for consistent weed control in no-till dryland production systems of western Kansas, where late-season control of Palmer amaranth (*Amaranthus palmeri* S. Watson), kochia [*Bassia scoparia* (L.) A. J. Scott], and foxtails (*Setaria* spp.) can become very challenging. Field experiments were conducted at the Kansas State University Agricultural Research Center, Hays, KS, during the 2025 growing season using a completely randomized block design with six treatments and four replications to compare spray drone and ground-based herbicide applications for late-season weed control in soybean (*Glycine max* [L.] Merr.). Treatments included glyphosate at 1.3 kg ae ha^{-1} in mixture with lactofen at 0.2 kg ai ha^{-1}, applied via spray drone at two spray volumes (2 or 3 GPA corresponding to 18.7 and 28.0 L ha^{-1}, respectively) and two droplet sizes (300 or 400 µm), along with a conventional ground sprayer using AIXR 11002 nozzle at15 GPA and a nontreated control. All treatments were applied at RI soybean growth stage. Data on weed control and soybean injury collected at 4 and 6 weeks after treatment (WAT) and soybean yield harvested at physiological maturity were subjected to ANOVA using the R package 4.5.0, and treatment means were separated using Tukey's HSD test at the 5% significance level. Spray drone-based applications achieved excellent foxtail control (98-100%) at both 4 and 6 WAT which was greater than that of the ground-based sprayer (83-85%). Palmer amaranth control ranged from 40-63%, and kochia control ranged from 39-64%. The highest control of both species (63-64%) occurred with spray drone application at 18.7 L ha^{-1} and 400 µm, which was statistically equivalent to the ground sprayer (55-58%). Soybean injury with spray drone and ground-based applications ranged from 19-36% at 4 WAT but decreased to 10-20% by 6 WAT and did not impact soybean yield at harvest. The observed injury symptoms were characteristic of PPO-inhibiting herbicides applied to glyphosate-resistant soybean, indicating acceptable crop tolerance under the evaluated conditions. All spray drone- treatments produced soybean yields (1109-1412 kg ha^{-1}) comparable to the ground sprayer (1190 kg ha^{-1}). These results indicate that spray drones, operated at low spray volumes (18.7 and 28.0 L ha^{-1}), can provide weed control efficacy equivalent to or greater than that of conventional ground applications while maintaining acceptable crop safety, demonstrating their potential as a practical complement to ground-based sprayers for late-season control of problematic weeds in no-till dryland soybean production systems. Future research should evaluate the influence of herbicide application timing, drone flight height, and travel speed on spray deposition, canopy coverage, and weed control efficacy to optimize spray drone application strategies in dryland environments.

41 - Spray Equipment (Drone vs Ground Sprayer) and Droplet Size Effects on a Full-Season Herbicide Program in Corn

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Spray drones are a relatively new technology, and their adoption is rapidly increasing in the United States. However, no research is available in the literature on the use of spray drones alone for full-season weed management. Therefore, the objective of this study was to evaluate a full-season herbicide program in corn (*Zea mays* L.) applied using a spray drone or a ground sprayer. The study was conducted in West Lafayette, IN, in 2025 and was organized as a completely randomized block design, with four replications and seven treatments. Treatments included a nontreated control, spray drone with two assumed swath widths (9.1 and 4.6 m) and two droplet size classifications (Fine and Coarse; XR110015 and AIXR110015 nozzles, respectively), and a ground sprayer with a 9.1 m boom width and Fine or Coarse sprays (ER11004 and MR11004 nozzles, respectively). All drone treatments were applied using a DJI Agras T30 calibrated to deliver 28 L ha^{-1} from a height of 3.7 m above the crop. The ground equipment was a Capstan PinPoint 3, pulse width modulation sprayer operated with a carrier volume of 140 L ha^{-1}, and the boom was positioned 60 cm above the crop. All treatments received the same preemergence and postemergence (corn V6 growth stage) herbicides, as well as included a fluorescent tracer dye (600 µg ml^{-1}). Acetate cards were spaced every 76 cm along a transect that was 11 m long, approximately 15 cm above the ground surface, and oriented perpendicular to the flight path to assess spray deposition. Visual weed control was evaluated weekly at the plot centers. Data were analyzed in R using a generalized linear mixed model. Drone deposition patterns exhibited a non-uniform, bell-shaped distribution with maximum deposition shifted slightly downwind of the flight path due to wind influence, and typically exceeded the maximum deposition observed from the ground sprayer. In contrast, the ground sprayer had less total deposition in some regions of the spray pass but maintained a more uniform deposition pattern across the entire swath. Two weeks after the postemergence application, all treatments provided ≥91% *Echinochloa crus-galli* (L.) P. Beauv. and *Setaria faberi* Herrm. control, except for the spray drone treatment with a 4.6 m swath width and Coarse spray, which resulted in 88% control. At the same evaluation, ivyleaf morningglory (*Ipomoea hederacea* Jacq.) control was ≥98% for both ground sprayer treatments, comparable only to the treatment with a 9.1 m swath width and Coarse spray. Control provided by the other treatments ranged from 88% to 92%. These results demonstrated that both spray drones and ground sprayers provided high levels of weed control from a full-season program. However, additional research is needed to develop strategies that achieve a more uniform deposition pattern across the swath for drone applications.

42 - Waterhemp (*Amaranthus tuberculatus*) control and spray droplet coverage with various spray volumes applied with a drone

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Herbicide applications with drones are gaining popularity across the North Central Region. One of the key weed species that growers are trying to control with these applications is waterhemp (*Amaranthus tuberculatus*). A large-scale field experiment was conducted in Michigan in 2024 and 2025 to examine the effects of spray volume and application speed on waterhemp control. In 2024, 7.6 m wide by 152 m long plots were established for drone herbicide applications when 'Enlist E3' soybeans were at the V4-V5 soybean stage and glyphosate-resistant (GR) waterhemp averaged 20-cm (5-45 cm) tall. In 2025, soybeans were at the V3 stage and waterhemp averaged 13-cm (13-25 cm) tall. Herbicide treatments consisted of glufosinate (682 g ha^{-1}) + glyphosate (1.26 kg ha^{-1}) + liquid ammonium sulfate (2.5% v/v) was applied at (1) 178 l ha^{-1} with a ground rig, and at (2) 18.7 l ha^{-1} at 9.5 m sec^{-1} (normal speed), (3) 28 l ha^{-1} at 9.5 m sec^{-1}, (4) 46.8 l ha^{-1} at 9.5 m sec^{-1}, (5) 18.7 l ha^{-1} at 6.99 m sec^{-1} (slow speed), and (6) 46.8 l ha^{-1} at 6.99 m sec^{-1} (slow speed) with a drone. In 2025, additional treatments were 2,4-D choline salt (1.06 kg ha^{-1}) premixed with glyphosate (1.26 kg ha^{-1}) + liquid ammonium sulfate (2.5% v/v) applied at the normal speed at (1) 18.7 l ha^{-1}, (2) 28 l ha^{-1}, and (3) 46.8 l ha^{-1}, also compared with a ground rig application. The drones used were a XAG P100 Pro 2023 in 2024 and a XAG P150 agricultural drone in 2025. Each treatment was replicated 4 times. At 14 days after treatment (DAT) weed control was evaluated. Evaluations were taken at three different areas in each plot as subsamples. In 2024, the greatest waterhemp control with glufosinate was 72% applied at the slower speed with a UAV at 46.8 l ha^{-1}. This was similar to the ground rig at 178 l ha^{-1}. Also, the 28 and 46.8 l ha^{-1} applications at the normal speed were similar to the ground rig. In 2025, the ground rig had a clear advantage of 77% waterhemp control with glufosinate compared with all drone applications. The higher spray volume (46.8 l ha^{-1}) resulted in ~65% control for both applications speeds and was consistently higher than the lower spray volumes. Waterhemp control from 2,4-D choline applications with the drone was greater than similar drone spray volumes with glufosinate and was similar for the higher spray volume with the drone (79%) and the ground rig (84%). Overall, a minimum of 46.8 l ha^{-1}, regardless of application speed, was needed to provide GR waterhemp control with both glufosinate and 2,4-D choline. Control at this spray volume was similar to the ground rig with 2,4-D choline (1/1 years) and glufosinate (1/2 years). However, GR waterhemp control was unacceptable and additional control measures would be needed.

43 - Comparing Application Performance of a UAV and Ground Sprayer for Pre-emergent Herbicide Application in Soybean

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Unmanned aerial vehicles (UAV) are a relatively new technology that are being adopted for their use in herbicide applications. As adoption of UAV increases, there is a need for research that can help the industry understand how UAV applications compare to traditional methods of herbicide application such as ground sprayers. Pre-emergent (PRE) herbicide applications play a crucial role in soybean (Glycine max) production by helping to maintain yields and mitigate and/or manage herbicide resistant weed species. A field experiment was conducted in both 2024 and 2025 to assess the performance of a PRE application of 25 g saflufenacil ha^{-1} + 70 g imazethapyr ha^{-1} + 119 g pyroxasulfone ha^{-1} using a DJI Agras T40 UAV with two application volumes (19 or 47 L ha-1) and two heights above canopy (1.5 or 3 meters). The same PRE herbicide treatment was applied with a ground sprayer equipped with TeeJet

AIXR11005 nozzles calibrated to deliver 140 L ha^{-1} for comparison. The experiment was conducted in a randomized complete block design with 4 replications and plots measuring 7.6 x 61 m. Water sensitive spray cards were placed at 1.5-m intervals on two lines perpendicular to the length of the plot. Visual weed control ratings were taken 7, 14, 28, and 42 days after crop emergence (DAE). UAV treatments exhibited significantly less spray coverage compared to ground sprayer treatments in both 2024 and 2025. However, off-target herbicide movement was not different between UAV and ground sprayer treatments. Ground sprayer treatments resulted in significantly higher visual weed control than UAV treatments in all years and locations. When comparing UAV parameters, an application volume of 47 L ha^{-1} resulted in higher visual weed control than 19 L ha^{-1} at 28 and 42 DAE but no differences in visual weed control were observed in response to application height. Overall, results indicate that ground sprayer treatments exhibited higher spray coverage which correlated with higher weed control from the PRE herbicide application. However, increasing the UAV application volume to 47 L ha^{-1} improved spray coverage and weed control at some locations along the swath width.

44 - Influence of Crop and Weed Canopy on Spray Deposition and Coverage of Understory Weeds

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Spray interception by plant canopy is an often-overlooked factor that can influence herbicide coverage on lower plant parts and late-emerging small weeds. As crop and weeds grow and leaf areas expand, spray droplets are increasingly filtered by upper canopy layers, limiting penetration to its lower portions. This study quantified the relationship between plant height and spray coverage loss in soybean production and compared interception patterns between crop and weed canopies. Field experiments were conducted in 2024 at Brooklyn and Janesville, Wisconsin, using AIXR110015 nozzles operated at 276 kPa (coarse droplet classification) with a carrier spray volume of 140 L ha^{-1}. Spray coverage on water-sensitive papers at the crop and weed canopy bases (soil level) was modeled against soybean height using a two-parameter log-logistic model for crop-only interception and a two-parameter Weibull model when both crop and weed interception occurred (both models had lower asymptote fixed at 0, and upper to 100%). Coverage declined as soybean height increased (negative slopes). Effective dose (ED) estimates described the soybean and weed heights where spray coverage was reduced by 10, 50, and 90%. Under weed free conditions, the ED_{50} occurred at 14.7 cm in Brooklyn and 15.7 cm in Janesville. These results indicate that under the evaluated spray setup, applications made before soybeans reach approximately 15 cm (V2-V3 growth stage) in height maintain higher coverage on lower canopy surfaces. Beyond this height, spray penetration decreases rapidly as soybean canopy develops. Interception patterns were evaluated under weed-infested conditions. In Brooklyn, where waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] predominated, the soybean canopy intercepted 50% of the spray at 11.5 cm (ED_{50}), and 90% at 23.2 cm (ED_{90}), while the waterhemp canopy reached ED_{50} at 10.7 cm and ED_{90} at 34.5 cm. In Janesville, infested by giant ragweed (*Ambrosia trifida* L.), the soybean canopy reached ED_{50} at 8.6 cm and ED_{90} at 15.5 cm, whereas the giant ragweed canopy reached ED_{50} at 11.0 cm and ED_{90} at 29.6 cm. These differences likely reflect canopy architecture. Giant ragweed's broader leaves and upright growth create layered, early-occluding canopies that accelerate interception within the crop-weed interference. Consequently, the interception by soybean reached ED_{50} at a lower height in Janesville (8.6 cm). At Brooklyn, waterhemp's

generally slower growth early on, and more open branching pattern likely allowed for more spray deposition, consistent with the higher soybean ED_{50} (11.5 cm) and slightly higher ED_{90} by waterhemp (34.5 cm). Results herein highlight the importance of deploying POST applications sooner rather than later to minimize herbicide spray interception. POST applications made before soybean exceeds ~15 cm in height (or V2-3 growth stage) may yield the most optimal coverage. Reduced deposition and coverage on lower canopy and understory weeds, particularly for contact herbicides such as glufosinate, may lead to sub-lethal herbicide exposure, increasing the risk of poor control and potential for resistance evolution.

Poster Section – Horticulture and Specialty Crops

45 - Effect of Application Timing on Peppermint (Mentha x piperita) Tolerance to Ethofumesate Post-Cutting Under Greenhouse Conditions

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Peppermint (*Mentha* × *piperita* L.) is commercially cultivated for oil production, but weed interference can significantly reduce yield and quality. Peppermint is especially sensitive to weed interference after harvest when the entirety of the crop canopy is removed. Ethofumesate is a soil-applied herbicide not currently registered for use in mint that may provide weed control between harvest and when the crop reestablishes a full canopy. Understanding the effect of application timing is essential to optimize weed management while minimizing crop injury. In 2025, research was conducted in two experimental runs at the Purdue University Horticulture Greenhouses, West Lafayette, IN to determine the effect of ethofumesate application timing on 'Redefined Murray Mitcham' peppermint. Established peppermint in 20-cm-diameter polyethylene pots was subjected to a simulated harvest by removing aboveground biomass at the substrate surface; then, ethofumesate (1260 g ai ha^{-1}) was applied at 0, 3, 8, 14 and 21 days after harvest (DAH). A non-treated control was included for comparison. The experiment design was a randomized complete block with four replicates. Data collected at 1, 2, 4, 6, and 8 weeks after treatment (WAT) included crop injury on a scale of 0% (no injury) to 100% (crop death) and crop height (5 shoots pot^{-1}). At 8 WAT the study was terminated; aboveground biomass was removed and dried. Plants were removed from their pots, and root injury was recorded on the aforementioned 0 to 100% scale. All data were analyzed using R software. ANOVA was performed using the *car* package, and regression analysis was conducted to generate predictive models. Pooled across both experimental runs, ethofumesate applied at 0 DAH caused 52% injury at 1 WAT, decreasing to 6% at 8 WAT, while plant height increased from 6 to 36 cm. Applications at 3, 8, 14, and 21 DAH showed similar recovery trends, with injury decreasing from 50, 33, 30, and 31% at 1 WAT to 7, 5, 3, and 4% at 8 WAT, respectively. Corresponding heights increased from 8, 11, 15, and 17 cm at 1 WAT to 33, 31, 36, and 32 cm at 8 WAT. Aboveground dry biomass of the nontreated check was 42 g pot^{-1} and decreased from 33 to 26 g pot^{-1} as ethofumesate spray timing increased from 0 to 21 days. Results from this trial showed that ethofumesate applied at 1260 g ai ha^{-1} was safe for peppermint across different application timings. However, applications made at least 3 days after harvest are recommended to minimize crop injury.

46 - Pumpkin Responses to Cereal Rye Termination and Burndown

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Cereal rye is a popular cover crop in Indiana. However, some farmers have had difficulty integrating this cover crop into a pumpkin production system, and a poorly managed cereal rye cover crop can harm pumpkin production as easily it can help. As such, it is vital to assess the best management practices for cereal rye cover crop termination when growing pumpkins. In 2025, a field study was conducted at two Indiana locations to evaluate the effects of cover crop termination method, burndown herbicide application, and nitrogen fertility on weed control and pumpkin crop response. The experiment design was a split-split plot with 18 treatments and four replicates. Main plots consisted of one of three cover crop termination methods at rye anthesis (roller-crimping, mowing, or 1060 g/ha glyphosate). Sub-plots consisted of burndown applications (no burndown, 882 g/ha glufosinate, or 1060 g/ha glyphosate) 1 week before planting. Sub-sub plots consisted of one of two nitrogen fertilizer application rates (168 kg/ha or 111 kg/ha nitrogen). Two 'Bayhorse Gold' pumpkin seeds were planted in each of 12 planting holes per plot (3 row plots, each containing 4 planting holes). The pumpkin stand was thinned to 1 seedling per hole 2 weeks after planting (WAP). Weed control data was rated visually on a scale of 0% (no weed control) to 100% (total weed control) at 1, 2, 4 WAP and 3 weeks prior to pumpkin harvest. Grass and broadleaf weed densities were also recorded. Pumpkins were harvested, graded into orange, green, immature, and non-marketable categories and weighed. All data was subjected to ANOVA and a mean comparison was performed using Tukey's HSD test. In vegetative data taken at 4 WAP, there were no significant differences in number of broadleaves regardless of treatment. Greater grass control was observed when rye was terminated with glyphosate compared to mowing. Additionally, a burndown application of glufosinate or glyphosate provided greater grass control than when no burndown herbicide was applied. Herbicide termination significantly improved percent weed control (78%) when compared to roller-crimp (66%) or mow (60%) termination of rye. Glufosinate and glyphosate significantly improved weed control (73% and 80% respectively) when compared to no burndown (51%). Orange pumpkin number was significantly improved with roller-crimping termination compared to mowing. Both crimping and glyphosate termination significantly improved orange pumpkin mean fruit weights when compared to mow termination. Both glyphosate and glufosinate significantly increased orange pumpkin number (both 12 pumpkins per plot) in comparison to no burndown (8 per plot). Nitrogen fertilization rates did not have a significant effect on any data. Immature, green, and non-marketable pumpkins were not significantly affected by any variable. These results suggest that roller-crimping or glyphosate termination of rye may be preferable in a pumpkin production system in comparison to mowing, and that glyphosate or glufosinate burndown would be beneficial.

47 - Performance of Terbacil on Newly Established Caneberries

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Weed management in caneberry, raspberries (*Rubus idaeus* L.) and blackberries (*Rubus fruticosus* L.), production is challenging due to limited weed control options, particularly during the establishment year. Terbacil, a broad-spectrum herbicide, is currently labeled for use in caneberries established for at least one year. Field experiments were conducted in 2024 and 2025 in Wooster, OH to evaluate crop safety and weed control efficacy of terbacil on newly planted caneberries. A randomized complete block design with four replications was used. Four terbacil rates were evaluated: 0.22, 0.45, 0.67, and 1.33 kg a.i. ha^{-1}. Treatments were applied as directed sprays to both sides of the row in a 1.8 m swath. Caneberries were planted on May 14, 2024, and poly-coated cane covers were installed prior to the 2024 herbicide applications. Applications were made 6 and 70 days after planting (DAP) in 2024. Cane covers were removed before the 2025 applications, which were made 14 days before and 74 days after primocane emergence. No visible crop injury was observed at any terbacil rate or application timing in both years. In 2024, control of annual grass weeds 15 days after treatment (DAT) averaged 84 to 86% for terbacil at 0.22 and 0.45 kg a.i. ha^{-1}, and 93 to 95% for 0.67 and 1.33 kg a.i. ha^{-1}. No significant differences were observed among treatments for any broadleaf weed species evaluated at 15 DAT. The second application of terbacil improved overall weed control and all treatments provided 91 to 98% control at 15 and 30 days after the second application. In 2025, all treatments provided more than 90% overall weed control. Blackberry and raspberry crop yield did not differ among treatments tested. These results indicate that terbacil can be safely used in caneberries during the establishment year and provide effective weed control without reducing yield in the following year.

48 - Planting Date Effects on Waterhemp (*Amaranthus tuberculatus*) Management in Dry Edible Beans

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Climatic shifts in Michigan, resulting in earlier planting times, are becoming increasingly common across the state. Dry edible beans are an excellent fit for these shifting patterns, considering they reach maturity within roughly 100 days. The potential for early planting also comes with questions surrounding weed management. Waterhemp (*Amaranthus tuberculatus*) is a growing concern among dry bean producers, with very few chemical tools available. A field experiment was established in 2024 and 2025 in Shiawassee County, MI to investigate potential cultural and chemical strategies for waterhemp control associated with planting dry beans earlier than the typical June planting time. The experiment was set up as a split-plot randomized complete block design with planting date as the main-plot factor and weed control programs as the sub-plot factor. The two planting dates included "early" (3rd week of May) and "normal" (1st week of June). Herbicide programs included: (1) PPI pendimethalin (1,060 g ha^{-1}) + dimethenamid-P (578 g ha^{-1}) only, (2) the PPI treatment followed by (fb.) POST imazamox (35 g ha^{-1}) + bentazon (733 g ha^{-1}), or (3) POST imazamox + bentazon + dimethenamid-P (526 g ha^{-1}), or (4) POST imazamox + bentazon + dimethenamid-P fb. late postemergence (LPOST) fomesafen (280 g ha^{-1}) ~5 d after POST. Weed control was evaluated 21 d after POST. Waterhemp and other weeds were counted and harvested at peak weed biomass. Dry bean stand was evaluated in both years, and yield was collected in 2025. Across both years, dry bean stand was >23% lower for early planted dry beans compared with the normal planting, and the dry bean stand for the untreated control was >30% lower compared with all herbicide programs. Early planted dry beans with overlapping residual and normal-planted dry beans with a PPI exhibited the best waterhemp control 28 days after POST both years. All treatments with PPI herbicide reduced waterhemp biomass by >80%. Dry bean yields were not different across herbicide programs but resulted in >87% higher yields than the untreated control. Results from 2024 and 2025 suggest that the later establishment of dry beans resulted in higher early-season control of waterhemp compared with early planting. However, appropriate herbicide treatments when dry beans were planted early helped with waterhemp control. There was no benefit in dry bean yield between either of the planting times in 2025.

49 - A Comparison of Pre- and Post-Planting Weed Management Strategies for Small-Scale Onion Production

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Weed management presents a critical challenge for producers of high-value vegetable crops like onions (*Allium cepa* L.). For small farm operators especially, minimizing both herbicide inputs and manual labor is essential for profitability and sustainability. This study was designed to evaluate the performance of different weed management strategies and their impact on weed populations, hand-weeding labor requirements, and crop yield. A field study was conducted over two experimental runs in 2025 at the Purdue University Student Farm, West Lafayette, IN. Treatments were arranged as a factorial of five pre-plant strategies by two in-season hand tools. The pre-plant treatments were: 1) 3 weeks of clear tarping followed by (fb) 2 weeks of silage tarping; 5 weeks of clear tarping fb either 2) glyphosate (772 g ai ha-1), 3) flame-weeding, or 4) caprylic acid-based organic herbicide (12.1 kg ai ha-1); and 5) a non-treated bare ground control. Hand tools included a tine harrow and Q-hoe. The experiment utilized a randomized complete block design with four replicates. Seventy-two 'Hamilton' onions were transplanted per 2.4 m^2 plot three days after pre-plant treatment application. Hand tools were used on 2, 4, and 6 weeks after transplanting (WAP) and followed by hand-weeding to remove escaped weeds. Data collection included weed density, hand-weeding time, and onion bulb number and weight. Data were subjected to ANOVA with treatment and experimental run as factors. Mean separations were performed using Tukey’s HSD ($\alpha = 0.05$). While post-plant cultivation was a factor, its interaction with pre-plant treatments was not statistically significant ($P>0.05$) for any measured variable. Pre-plant strategy significantly influenced season-long aggregate weed density ($P<0.001$), with henbit (*Lamium amplexicaule* L.), common chickweed (*Stellaria media* L.), carpetweed (*Mollugo verticillata* L.), and Pennsylvania smartweed (*Polygonum pensylvanicum* L.) being the most prevalent weed species identified. Clear tarping followed by silage tarping was the most effective, resulting in the lowest total weed pressure (408 plants m^{-2}). Clear tarping fb glyphosate offered the next best control (843 plants m^{-2}), while clear tarping fb flame-weeding provided intermediate suppression. The caprylic acid treatment was ineffective and statistically similar to the non-treated control, which had the highest weed pressure (1,581 plants m^{-2}). Clear tarping fb glyphosate or silage tarping required the least hand-weeding labor over the duration of the growing season (4.2 and 4.4 minutes m^{-2}, respectively). The non-treated control and caprylic acid treatments demanded the most labor, requiring over 10 minutes m^{-2} of hand-weeding during the growing season. Onion bulb number was not affected by treatment; however, yield was significantly impacted ($P<0.001$). Clear tarping fb silage tarping produced the greatest yield (6.0 kg m^{-2}). While effective for weed control, glyphosate resulted in the lowest onion yield (4.9 kg m^{-2}) due to crop phytotoxicity. In conclusion, clear tarping fb silage tarping proved to be a highly effective, non-chemical pre-plant strategy for integrated weed management in transplanted onion. It provided superior weed suppression, significantly reduced labor requirements by 68% compared to the control, and enhanced crop yield, offering a sustainable and economically viable solution for growers.

50 - IR-4 Project: Success and Benefits to Specialty Crop Growers

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[1]IR-4 Project

For more than 60 years, the IR-4 Project has helped growers/farmers of specialty crops (fruits, vegetables, nuts, herbs, spices, ornamentals and other horticultural crops) gain access to registrations of safe and effective chemical and bio-based herbicides, fungicides and insecticides. The IR-4 Project remains relevant because the crop protection industry focuses their research and development efforts on products that provide large sales that yield adequate return on investment. They shy away from specialty crops because of the cost of development of the data required for registration. The IR-4 Project fills this gap of developing data utilizing a network of public sector researchers (University and USDA-ARS) with expertise in pest management and analytical chemistry. Since its inception, IR-4 has secured over 23,000 registrations of crop protection products in food crops and over 56,000 uses in ornamental crops under its Environmental Horticulture program. IR-4 contributes nearly $9 billion to the annual US gross domestic product, according to a 2022 report by the Michigan State University Center for Economic Analysis.

IR-4 activities include, but are not limited to:

Food Crop Program: Facilitates regulatory approval of pest management solutions for specialty food crops through three research platforms:

- Residue Studies - determining the amount of chemical pesticide remaining in the crop at harvest;
- Product Performance - developing data to show that a potential use of a pesticide is safe and effective; and
- Integrated Solutions - utilizing multiple tactics including chemical pesticides, biopesticides, emerging technologies and other tools in combination to manage critical pests.

Environmental Horticulture Program: Supports regulatory approval of pest management solutions for environmental horticultural crops including landscape/nursery plants, cut flowers and more.

Biopesticide Regulatory Support: Aids in development and registration of bio-based pesticides for use on specialty crops.

International Activities: Facilitates the international harmonization of Maximum Residue Levels (MRLs), supporting U.S. specialty crop growers in accessing export markets. IR-4 also helps build capacity of global minor use programs and collaborates with international partner organizations.

For more information, please visit our website: https://www.ir4project.org/

51 - Fall or Spring: When is the Best Time for Herbicide Applications in Winter Wheat?

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Herbicide applications in winter wheat are typically made in the spring. However, cold and wet conditions can delay field access, pushing applications past optimal timings for both weed control and crop safety. Longer autumns due to shifting climatic patterns allow growers to distribute fieldwork between fall and spring but also promote additional winter annual weed growth. Limited information exists on how planting date and fall application timing interact to affect weed control and crop tolerance under Michigan conditions. The objective of this research was to evaluate and compare weed control and crop tolerance from fall versus spring herbicide applications in early- and late-planted wheat. Field experiments were established at the Michigan State University (MSU) Agronomy Farm in East Lansing, Michigan, (MSU-23, MSU-24, MSU-25), and at the Saginaw Valley Research and Extension Center near Richville, MI, (SVREC-24, SVREC-25) for a total of five site-years. The main plot factor was herbicide application timing within planting date and the sub-plot factor was herbicide treatment. Herbicide treatments consisted of pyrasulfotole + bromoxynil alone, and tank-mixed with mesosulfuron. Wheat was planted in mid- to late-September (early) and 4 wks later (late). Herbicide treatments were applied in the fall at wheat Feekes stage 1.2 to 1.3 and in the spring (Feekes 5) for both early and late planted wheat. There was an additional fall application timing for the early planted wheat at Feekes stage 2. At MSU, injury 14 days after treatment (DAT) was influenced by herbicide treatment and planting date-application time. Wheat injury 14 DAT was 12% when mesosulfuron was included in the herbicide treatment and applied at Feekes stage 1.3 for early planted wheat. No other fall herbicide applications resulted in significant crop injury. However, at SVREC-25, the addition of to the spring application of mesosulfuron caused 10% injury in the later planted wheat, 14 DAT. At MSU-23 and MSU-24, delaying planting by 4 wks resulted in 43-50% less weed biomass in mid-May in the untreated control. Additionally, all herbicide treatments regardless of application timing reduced weed biomass compared with the early-planted untreated control and all fall applications reduced weed biomass compared with the late-planted untreated control. At MSU-25, weed biomass was greater in the later planted wheat and only the main effect of herbicide treatment was significant compared with the untreated control. The early-planted wheat reached 50% canopy closure eight days sooner than late-planted wheat in three of the four site-years. In three out of five site-years, herbicide application timing affected winter wheat yield. At MSU-23 and SVREC-24, early planted wheat out yielded the later-planted wheat, regardless of application timing. At SVREC-25, yield was greater for the early planted wheat, however the addition of mesosulfuron was applied in the spring to the late-planted wheat resulted in lower yield than the untreated control. Overall, timely fall herbicide applications for early planted wheat, may be the most effective strategy for weed control. Spring applications remain an option but fall herbicide applications appear more reliable especially when weather limits spring field access.

52 - Using Cereal Rye Cover Crop for Weed Control in Vegetable Production Systems.

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Field experiments were conducted in 2025 to optimize cereal rye (*Secale cereale* L.) and hairy vetch (*Vicia villosa* Roth) mix cover crop integration in vegetable crop production. Effect of cover crop and termination methods crop yield (tomato, pepper, cucumber, and pumpkin) and weed control (pepper) were evaluated in Fremont and Wooster, OH. A factorial split-plot design with four replications was used with the presence or absence of cover crop as main factor. Split plot factor included three cover crop termination methods; 1) cover crop terminated with glyphosate, 2) glyphosate plus roller crimper, and 3) glyphosate plus flail mower. Tomato and pepper were transplanted, and cucumber and pumpkin were direct seeded two weeks after termination. S-metolachlor and sulfentrazone in tomato, S-metolachlor and clomazone in pepper, clomazone, ethalfluralin, and S-metolachlor in cucumber, and clomazone and ethalfluralin in pumpkin were applied preplant. No postemergence herbicide was used. Due to significant interaction between main crops and locations, data were analyzed separately for each crop in each location. At Fremont, pepper, cucumber, and pumpkin yield did not differ between cover crop and termination treatments. Cover crop decreased tomato yield (21,605 kg ha^{-1}) by 55% compared with no cover crop (48,389 kg ha^{-1}). At Wooster, cover crop increased tomato yield (59,920 kg ha^{-1}) by 92% compared with no cover crop (31,243 kg ha^{-1}). There was a significant interaction between cover crop and termination method for pepper, cucumber, and pumpkin yield at Wooster. Overall, pepper, cucumber, and pumpkin yields were lower in plots where cover crop was terminated with glyphosate plus flail mower compared to glyphosate alone or glyphosate plus roller crimper. Weed aboveground biomass and plant density at four weeks after pepper planting (WAP) did not differ between cover crop treatments. At 12 WAP, cover crop had 84% higher biomass (887 g m^{-2}) and 309% higher density (45 plants m^{-2}) than no cover crop. These results indicate that the effect of cover crop on vegetable crop and weed is likely dependent on the associated management practices.

53 - Bioherbicides for Weed Control: Opportunities and Challenges

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A lack of new herbicide active ingredients on the market, combined with the rapid spread of herbicide-resistant weed populations in specialty crops, has necessitated the exploration of alternative solutions that reduce reliance on conventional weed control methods and mitigate weed pressure, particularly among those transitioning to organic farming. The proportion of bioherbicides approved for use in certified organic production systems in the United States and globally continues to increase, highlighting the growing need for effective and reliable alternatives. Moreover, a global shift toward more sustainable and environmentally conscious agricultural practices is driving efforts to reduce reliance on conventional pesticides by increasing the integration of biopesticides into weed management programs. In recent years, several new bioherbicides have been introduced; however, data on their efficacy and suitable tank-mix adjuvant partners remain limited, underscoring the need for further investigation to guide their implementation. To address this, five bioherbicides, including ammonium nonanoate, capric and caprylic acids, eugenol, d-limonene, and pelargonic acid, were tested in greenhouse studies on five weed species Palmer amaranth (*Amaranthus palmeri* [S.] Wats), velvetleaf (*Abuthilon teophrasti* Medic.), common lambsquaters (*Chenopodium album* L.), barnyardgrass (*Echinocloa cruss-galli* L.), and kochia (*Bassia scoparia* [L.]) Voss when plants reached 10-15 cm. The treatment list included four adjuvants: two non-ionic surfactants, a water-reducing adjuvant, and a non-ionic silicone surfactant [0.6 L ha^{-1} or 0.15 % v v^{-1}]. All treatments have been applied using the DG9503E nozzle set at 50cm height and calibrated to deliver 400 L ha^{-1} at 276 kPa. The study evaluated the percentage of biomass reduction at 21 days after application compared to the untreated control. Among the tested bioherbicides, ammonium nonanoate consistently delivered the highest biomass reduction across all species, reaching up to 98% on Palmer amaranth and maintaining robust activity on velvetleaf, kochia, and common lambsquarters (above 70%), without difference between added additives. Pelargonic acid and the blend of caprylic and capric acids also demonstrated high efficacy, generally providing 60-90% biomass reduction depending on the species. The significant additive effect on pelargonic acid was obtained for velvetleaf and common lambsquarters, as well as for kochia and c. lambsquarters applying capric and caprylic acids. In contrast, eugenol showed minimal activity, rarely exceeding 20% biomass reduction and showing no measurable effect on Palmer amaranth or common lambsquarters. The results indicate the potential for using certain bioherbicides as candidates to achieve satisfactory weed control. However, considering the non-selective nature of these products, targeted spray applications will be required to enable their practical use in both row and specialty crop production systems.

Poster Section – Pasture, Range & Vegetation Management

54 - Effects of PGR Rate and Timing on Roadside Turf

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Tall fescue (*Schedonorus arundinaceus* (Schreb.) Dumort., nom. cons.) is a widely adapted species and is commonly used on roadsides in the transition zone. Multiple mowings are the most common tall fescue management regime for transportation departments. Plant Growth Regulators (PGRs) could potentially reduce mowing while maintaining safe highway conditions. PGRs are currently classified into six categories, Classes A -F, based on their mechanism of action. Class D PGRs are herbicidal, and this trial included different rates and combinations that are being used along KY roads. The response is rate dependent and damage to the turf may occur with excessive overlap of spray passes, for example.

The trial was established July 7, 2025, at the Spindletop Research Farm in Lexington KY. It was arranged as a complete block design with 14 PGR treatments plus control and three replications. Plots were 2 m by 6 m with running unsprayed checks between each of the plots. PGRs were applied after the first mowing. The applications were at 234 L/ha and included a non-ionic surfactant at 0.25% v/v with the initial canopy height at 9 cm.

Products tested were Plateau (imazapic) by itself and in combination with Escort (metsulfuron), and Method (aminocyclopyrachlor) at 1X and 2X the target rates. Fusilade II (fluazifop) was also tested by itself and in combination with Plateau and Method at 1X and 2X the target rates.

Turf color was assessed by comparison to the running check strips. The color rating ranges from 0 (dead) to 9 (full green). The color of the check strips was set at 8. Canopy heights were measured through the growing season. Assessments were done 17 days after treatment (DAT) (7/24/2025), 37 DAT (8/13/2025), 65 DAT (9/10/2025), 91 DAT (10/6/2025), and 119 DAT (11/2/2025). Data were analyzed using ARM software and treatment means were compared using Fisher's LSD at p = 0.05.

At 17 DAT all the treatments had lower color ratings (4.5 to 6.7) and were shorter than control. The 2X rate of the lower rate of Plateau by itself, Plateau plus Escort plus Method, and Plateau plus Fusilade plus Method had lower color ratings. By 37 DAT all the treatments were still shorter than control, but some treatments were similar in color to control. However, additional 2X rate treatments had lower color ratings. These included the higher rate of Plateau by itself and Plateau plus Fusilade. By 65 DAT many of the treatments were similar in height to control but the 2X rate of the lower rate of Plateau by itself and Plateau plus Fusilade plus Method still had lower color ratings than the 1X rate.

Over the course of the season the fescue recovered from the 1X and 2X rates of application, but damaged turf is less competitive and aesthetically pleasing.

Poster Section – Row Crop Herbicides

55 - Integrated Management of Volunteer Corn in Corn

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Nebraska has approximately 3.5 million acres of corn (*Zea mays* L.) after corn in rotation each year. Volunteer corn often results from previous years lodging plants, dropped ears, and combine loss. Volunteer corn can lead to corn yield loss if not managed. Enlist® Corn is available commercially which is resistant to glyphosate, glufosinate, 2,4-D choline, and FOP herbicides, such as quizalofop. Quizalofop (Assure II) is labeled for control of volunteer corn in Enlist corn. A premix of glufosinate and quizalofop (Zalo) has recently been labeled for weed control in glufosinate-resistant soybean. Growers in Nebraska are using inter-row cultivator for weed control in 0.76 m row spacing corn. The objective of this study was to evaluate integrated management of volunteer corn in Enlist corn using quizalofop (Assure II), glufosinate/quizalofop (Zalo), and interrow cultivator at different growth stages of Enlist corn. A field experiment was conducted at the University of Nebraska-Lincoln's South Central Agricultural Laboratory near Clay Center, NE in 2025. Bin-run corn from 2024 harvest with glyphosate/glufosinate-resistant (Roundup Ready/LibertyLink) trait was cross-planted at 49,400 seeds ha^{-1} to mimic volunteer corn. Enlist® corn was then planted at 86,450 seeds ha^{-1} with 0.76 m row spacing. Treatments evaluated single and multiple inter-row cultivation at Enlist corn growth stages V2 up to V8, and FOP based herbicides applied alone or followed by inter-row cultivation. The results of this research indicate that inter-row cultivation and POST herbicides (quizalofop and glufosinate/quizalofop) were equally important to achieve greater than 95% control of volunteer corn in Enlist corn. A premix of glufosinate/quizalofop is not yet labeled for control of volunteer corn in Enlist corn; therefore, cannot be recommended.

56 - Winger: New Pyroxasulfone Formulations from UPL NA Inc

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[1]UPL

Pyroxasulfone is a Group 15 herbicide known for its effective residual control of small - seeded broadleaf and grass weeds in corn, soybean, and various other crops. Upon EPA registration, UPL will introduce two pyroxasulfone formulations under the brand name Winger. Replicated field trials conducted across the Midwest have demonstrated that Winger provides effective and consistent control of key small-seeded broadleaf and grass weeds. These trials also confirmed favorable crop safety. Performance comparisons indicate that Winger delivers comparable weed control efficacy and crop tolerance with commercially available pyroxasulfone products

57 - Do Soil Moisture at Application and Subsequent Rainfall Timing Dictate Preemergence Herbicide Efficacy?

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Preemergence (PRE) herbicides play a significant role in effective season-long weed management. However, their performance can vary depending on environmental conditions at and following application. In years with excessive rainfall, PRE herbicides are prone to losses through leaching and runoff, while in dry years, insufficient soil moisture can prevent proper herbicide incorporation and subsequent availability for weed control in soil solution. Consequently, some growers perceive PRE applications as a potential risk or inefficient use of resources. The objective of this greenhouse study was to evaluate the soil residual control efficacy and consistency of multiple G15 herbicides exposed to varying soil moisture conditions, using giant foxtail (*Setaria faberi*) as the bioindicator species. A factorial experiment was conducted with six PRE herbicide treatments, including S-metolachlor (Dual II Magnum [1.784 g a.i. ha^{-1}]), dimethenamid-P (Outlook [945 g a.i. ha^{-1}), pyroxasulfone (Zidua [128 g a.i. ha^{-1}]), non-encapsulated acetochlor (Harness [1.260 g a.i. ha^{-1}]), encapsulated acetochlor (Warrant [1.260 g a.i. ha^{-1}] and a non-treated control; two soil moisture conditions at PRE application (50% field capacity and dry); and five rainfall delay intervals (0, 3, 7, 14, and 21 days after PRE application). The study was arranged in a completely randomized design with six replications and conducted in two separate runs. Experimental units consisted of 7.5x7.5 cm pots filled with field soil (silt loam soil) maintained under greenhouse conditions at 21-29 °C with a 16-hour photoperiod. Following PRE application conducted in a research spray chamber calibrated with a carrier volume of 140 L ha^{-1}, treatments requiring rainfall simulation received 22 mL pot^{-1} day^{-1}, corresponding to 3.7 mm day^{-1}. Twenty-one days after PRE

application, all pots were seeded with giant foxtail as a bioindicator, distributing approximately 60 seeds per pot evenly across the soil surface and pots were watered daily after planting. Harvest was conducted 28 days after seeding. The results indicate that dimethenamid-P provided high (>91% biomass reduction) and consistent control across soil moisture levels and rainfall delay intervals, exhibiting less variability overall, while S-metolachlor and non-encapsulated acetochlor also reduced biomass by more than 85%, regardless of conditions. In contrast, encapsulated acetochlor and pyroxasulfone showed greater variability in both density and biomass reduction, showing a variable performance and <80% control across the tested soil moisture and rainfall scenarios. The encapsulated version of acetochlor provided less biomass and weed reduction compared to the non-encapsulated version, highlighting how active ingredient formulation can impact control. Finally, the random forest analyses indicate that herbicide selection was the primary factor affecting soil residual control of giant foxtail in this experiment, rather than soil moisture and subsequent rainfall timing. Strategic selection of preemergence herbicides can enhance the consistency and reliability of weed control performance under diverse climatic conditions.

58 - Do Postemergence Applications with Group 15 Herbicides Improve End-of-Season Waterhemp Control and Soybean Yield? Seven Years of Wisconsin Data

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Waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] is consistently ranked as one of the most troublesome weeds by Wisconsin farmers. A common recommendation to achieve season long control of waterhemp in soybean by both university extension and the crop protection industry has been to layer residual herbicides. In practice, this would typically include a pre-emergence (PRE) application of a multiple effective site of action herbicide followed by a post-emergence (POST) tank mixture that includes a group 15 herbicide (*S*-metolachlor, acetochlor, dimethenamid-P, or pyroxasulfone) for additional residual control. The Wisconsin Cropping Systems Weed Science extension lab has conducted several chemical manufacturer- and commodity board-sponsored soybean trials over the past seven years (2019-2025) that have assessed several combinations of two-pass, PRE followed by POST herbicide programs both with and without the inclusion of a group 15 herbicide in the tank at the POST application. Herein, our objective was to understand on a general level if the addition of a group 15 herbicide to the POST application improved end-of-season waterhemp control and soybean yield looking at our combined data across trials and years (33 total trials). All data were collected from trials established over the past six years (2019-2024) at the O’Brien Hybrids Farm located near Brooklyn, WI. The waterhemp population at this location is naturally occurring and is known to be resistant to glyphosate (group 9) and ALS (group 2) herbicides. Field sites had a sandy loam to loam soil texture ranging from 1.2-1.7 percent organic matter. Data were filtered to only include two-pass PRE followed by POST herbicide programs. Any POST program that included an herbicide with residual activity on waterhemp other than a group 15 herbicide, like fomesafen, were excluded from the analysis. Preliminary results indicate that across six years of Wisconsin data (2019-2024; data from 2025 (year 7) will be updated for the poster), end-of-season waterhemp control was 90% (±12 standard deviation [sd], n = 460) and 92% (±10 sd, n = 676) for POST herbicide tank mixes without and with a group 15 herbicide, respectively. Soybean grain yield was 3,972 kg ha^{-1} (±721 sd, n = 460) and 4,092 kg ha^{-1} (±720 sd, n = 676) for POST herbicide tank mixes without and with a group 15 herbicide, respectively. Thus, adding a Group 15 herbicide to POST tank mixes modestly increased end-of-season waterhemp control from 90% to 92% and average yield from 3,972 to 4,092 kg ha^{-1} across our trials.

59 - The Efficacy of Premixes and Application Timing in Reduced Atrazine Programs

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[1]The Ohio State University

Since its introduction, atrazine has been one of the most commonly applied herbicides in the United States, where it is used for pre and post-emergence control of broadleaf and some grass weeds in corn. Despite widespread use, it remains a controversial product, largely due to its potential for off-target movement. Regulatory reviews and potential restrictions may limit the application rate or potentially ban atrazine use altogether. Herbicide manufacturers have developed atrazine-free premixes to be used in preemergence (PRE) and postemergence (POST) applications, but efficacy trials and evaluation of atrazine timing with lower use rates are needed. The objective of this project was to evaluate herbicide programs consisting of two factors, five commercially available atrazine-free 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 timings (PRE, POST, none). This was a fully factorial randomized complete block design with 15 programs, and an untreated control (UTC) for a total of 16 treatments and 4 replications. The site was located at the Western Agricultural Research Station in South Charleston, Ohio. Applications were made with a CO^2 pressurized backpack sprayer. POST applications were applied to all plots with glyphosate + liquid ammonium sulfate. Evaluations consisted of herbicide efficiency (% control) and crop injury (% injured) 14 and 28 days after treatment (DAT), weed density (count $0.5m^{-2}$) 14, 28 DAT and at POST, and weed biomass (g) at final POST. Corn stand counts were conducted at V2, and yield was collected at the end of the season. Evaluation included all weeds found consistently in the field, primarily giant foxtail (*Setaria faberi* Herrm.), giant ragweed (*Ambrosia trifida* L.), velvetleaf (*Abutilon theophrasti* Medik.), common lambsquarters (*Chenopodium album* L.), and prickly sida (*Sida spinosa* L.). Data was analyzed in SAS 9.4 using the GLIMMIX procedure. For PRE applications, premix effectiveness varied by weed species. 28 DAT, giant foxtail control was greatest with treatment SMPB-PRE (91.25%), and lowest with treatment PS-POST (23.75%). Giant ragweed control ranged from 82.50% with SMPB-PRE to 18.75% with PS-PRE. After the POST application, all treatments had acceptable control (85%) of all weeds; however, 28 DAT-POST, some were significantly different. For giant ragweed, SMPB-PRE had the greatest control at 99.25% and was significantly different from FIT-PRE (90.00%). For prickly sida, PS-NONE had the greatest control at 99.5% and was significantly different from FIT-NONE (89.75%). For yield, the main deciding factor appears to be whether the plot received an application of herbicide, as the most consistent difference was between any premix and the UTC. At 28 DAT-PRE, not accounting for timing, the PS premix had less control than the other premixes. In common lambsquarters and velvetleaf, the PRE applications of SMPB, MCP, and AMC were not significantly different from FIT, which received an early POST. Results suggest that comprehensive atrazine free premix programs could be effective at controlling weeds but will largely depend on species. A second trial run will take place summer 2026.

60 - Optimizing Weed Control with Diflufenican in Soybean Production: The Impact of Tillage and Application Timing on Soil Residual Activity

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Effective management of *Amaranthus* species is a major challenge in soybean (*Glycine max* (L.) Merr.) production, partially due to the rapid evolution of herbicide resistance. The reduced efficacy of commonly used herbicide programs, due to resistant *Amaranthus* biotypes, highlights the need for soil-residual herbicides with alternative modes of action relative to current commercial standards. Diflufenican, a phytoene desaturase (PDS) inhibitor, may provide a new soil-residual herbicide option for controlling broadleaf weeds, particularly *Amaranthus* species. However, the efficacy of soil-applied herbicides can be influenced by environmental conditions or other crop management practices. Field research was conducted to determine: 1) how tillage system affects the residual activity of diflufenican and 2) how application timing influences soybean injury and broadleaf weed control from diflufenican. The experiment was conducted in a randomized complete block design with four replications and three factors: tillage type (reduced till and no-till), application timing (preplant and preemergence), and diflufenican rate (150 and 300 g ai ha^{-1}). Herbicides were applied using a 2-m wide handheld boom, calibrated for a spray volume of 140 L ha^{-1} at 172 kPa. Visual crop injury, weed control estimates, and stand counts were assessed at 14, 21, 28, and 42 days after planting (DAP). Weed counts and aboveground biomass was collected at 28 and 42 DAP. Data were analyzed with an analysis of variance and means separated using Tukey's Honestly Significant Difference test (α=0.05). Residual control of *Amaranthus* spp. (mix of *A. tuberculatus*, waterhemp and *A. retroflexus*, redroot pigweed) at 35 DAP was greatest with preemergence applications of diflufenican in a no-till system, with up to 99% control of *Amaranthus* compared to as little as 20% control from preplant applications in a tilled system. Diflufenican injury symptoms on soybean included leaf midvein bleaching and chlorosis, stunting, and injury ranged from 0 to 15% (150 g ai ha^{-1}) at 21 DAP. The soybean injury data from diflufenican followed similar trends to the weed control data, with the least soybean injury in the preplant applications. These results demonstrate that preemergence applications in a no-till system provided a balance of enhanced weed control and crop safety. Thus, diflufenican shows potential as a soil-residual herbicide for managing *Amaranthus* species in soybean production. This research will be repeated in 2026 to validate the consistency of diflufenican efficacy for weed control and soybean injury under different environmental conditions.

61 - Optimization of Rapidicil® Dose and Adjuvant Type for Control of Palmer amaranth (*Amaranthus palmeri*), cheatgrass (*Bromus tectorum*), common ragweed (*Ambrosia artemisiifolia*), and kochia (*Bassia scoparia*)

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Rapidicil® (epyrifenacil) is a postemergence, nonselective group 14 herbicide for winter broadleaf and grass weed control, primarily before planting corn and soybean. Dose-response studies of epyrifenacil were conducted at the University of Nebraska-Lincoln greenhouse to develop recommendations for application rate and adjuvant use. Treatments included epyrifenacil applied at five rates (4.9, 10.0, 19.9, 39.8, and 79.7 g ai ha^{-1}) alone or with adjuvants: methylated seed oil (MSO), crop oil concentrate (COC, Agri-Dex®), ammonium sulfate (AMS), and nonionic surfactant (NIS, Induce®). A total of 25 treatments were arranged in a completely randomized design with four replications. Applications were made using a spray chamber equipped with flat-fan nozzles calibrated to deliver 187 L ha^{-1} when weeds reached 10 cm in height. Four weed species were included in the study: Palmer amaranth (*Amaranthus palmeri* S. Watson), kochia (*Bassia scoparia* L.), common ragweed (*Ambrosia artemisiifolia* L.) and cheatgrass (*Bromus tectorum* L.). Visual control ratings (%) were collected 5 days after treatment, and aboveground biomass was harvested at the end of the study. Results indicated that epyrifenacil efficacy increased with rate and was strongly influenced by the choice of adjuvant. Including adjuvants improved control consistency across all weed species compared to using epyrifenacil alone. The dose required to cause 50% injury (E_{50}) was estimated using three-parameter logistic regression in the DRC package, which varied among weed species and adjuvant treatments. Epyrifenacil applied with NIS + COC provided the greatest enhancement with E_{50} values of 99.4%, 88.7%, 81.9%, and 89.9% for cheatgrass, common ragweed, kochia, and Palmer amaranth, respectively, compared with epyrifenacil applied alone. It is concluded that epyrifenacil efficacy improved with any adjuvant, and the NIS+COC mixture outperformed all others across all species.

62 - Dose-Response of Select Missouri Waterhemp Populations to Glufosinate, Dicamba, and 2, 4-D

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[1]University of Missouri

Glufosinate, dicamba, and 2,4-D are commonly relied upon for post-emergent waterhemp (*Amaranthus tuberculatus)* control in current soybean production systems. In recent years there have been multiple instances where applications of these herbicides have resulted in a lack of complete waterhemp control. To proactively address concerns of potential resistance to these herbicides, seed from >600 waterhemp populations were collected from soybean fields in eight states from 2018 to 2023 and subjected to an initial screen with one-half and labeled use rates of each of these herbicides. Based on the results from these screenings, 12 Missouri waterhemp populations were identified as potentially resistant to one or more of these herbicides and subjected to a complete dose-response to glufosinate, 2,4-D and dicamba. Applications of each herbicide were made to seedlings 10 cm in height. Visual injury ratings, survival counts, and biomass reduction was determined 15 days after application. Three of the Missouri waterhemp populations were found to be resistant to 2,4-D, with effective doses that result in 50% control of the population (ED_{50}) ranging from 1404 to 2029 g/ha. For dicamba, ED_{50} values from two of the populations were significantly different from and approximately 1.8 to 2.6-fold greater than that of the susceptible (S) waterhemp comparison, although none of the populations could be characterized as resistant. Results from the glufosinate dose-response experiments are ongoing and incomplete at the time of this submission but expected to be finalized within the next several weeks. Results from this survey will help to provide a greater understanding of the potential distribution of waterhemp with resistance to glufosinate, dicamba, and 2,4-D.

63 - Soil and Precipitation Effects on Preemergence Herbicide Efficacy on Waterhemp (*Amaranthus tuberculatus*) and Kochia (*Bassia scoparia*)

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Waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] and kochia [*Bassia scoparia* (L.) A.J. Scott] have become two of the most problematic weeds in North Dakota. Waterhemp has evolved multiple herbicide resistance to at least four sites of action across North Dakota and Northwest Minnesota. Kochia is resistant to at least four herbicide sites of action. Few effective foliar applied herbicides remain to control waterhemp and kochia. The utilization of preemergence herbicides can be a viable option for controlling these troublesome weeds. The objective of this experiment was to analyze the effects of soil and precipitation on preemergence herbicide efficacy on waterhemp and kochia. A greenhouse experiment was conducted using a randomized complete-block design (RCBD) arranged in a 5x3x2 factorial across two weed species. Factor A is the herbicide used, and consists of 5 levels; non-treated, 560 g ae ha^{-1} of dicamba, 105 g ai ha^{-1} of mesotrione, 280 g ai ha^{-1} of metribuzin, and 1260 g ai ha^{-1} of encapsulated-acetochlor. Factor B is precipitation amount, and consists of 3 levels; 0.635 cm, 1.27 cm, and 2.54 cm of simulated rainfall. Factor C is soil type and consists of 2 levels, Glyndon, MN (sandy loam with 2.1% OM) and Fargo, ND (clay with 5.1% OM). A waterhemp population from Fargo, ND and a kochia population from Griggs Co, ND were used in the experiment. Pots (10.2cm x 10.2cm x 12.5cm) were filled with soil and sub-irrigated until saturated 1 day prior to experiment initiation. Each pot was seeded with either 20 waterhemp or kochia seeds. Pots were then treated with herbicide followed by respective precipitation amounts. A fixed-track spray chamber was used to apply herbicides and simulate precipitation. Weed density counts and visible weed control using a scale of 0-100% control were taken 7, 14, 21, 28, and 35 DAT. Weed biomass was collected 35 DAT. Precipitation was not significant in relation to weed biomass. Metribuzin and dicamba treatments on the Glyndon soil type reduced kochia biomass by 100%. Metribuzin applied to the Fargo soil was comparable to applying mesotrione on the Glyndon soil which reduced kochia biomass by over 83%. Kochia biomass was greater on the Fargo soil type averaging 2.3 times more biomass than the Glyndon soil type. Waterhemp biomass was greater for Fargo soil treatments compared to Glyndon soil treatments because plants were completely controlled in Glyndon soil in run 1, and 9.1 times greater in run 2. Mesotrione, metribuzin, and encapsulated acetochlor were the most effective in waterhemp biomass reduction in run 1, while metribuzin and encapsulated-acetochlor were the most effective in waterhemp biomass reduction in run 2. These results indicate that soils with higher sand content and lower OM can allow for greater herbicide activity and subsequently have a higher reduction in weed biomass compared to soils with lower sand content and higher OM. Precipitation was not a factor in weed biomass reduction most likely due to precipitation regimes being within the recommended range of precipitation accumulation for the herbicides used in the experiment.

64 - 2,4-D and glufosinate applied alone or mixed during the day and night: weed control and soybean yield Implications

Eric Jones[1], Sachin Dhanda[1], Jill Alms[1], David Vos[1]

[1]South Dakota State University

Field experiments were conducted at Volga, South Dakota in 2023 and 2024 to determine the time-of-day effect on weed management and soybean yield with 2,4-D and glufosinate applied alone or in mixture. 2,4-D and glufosinate were applied at 1165 or 655 g ae/ai ha^{-1}, respectively. The mixtures included the rates applied singularly (2,4-D: 1165 g ae ha^{-1}; glufosinate: 655 g ai ha^{-1}) or with an increased glufosinate rate (855 g ai ha^{-1}) and the 2,4-D rate was held constant. Herbicide treatments were applied during the day at 1:00 PM while the night applications occurred at 9:00 PM. Common lambsquarters (*Chenopodium album*) and waterhemp (*Amaranthus tuberculatus*) were approximately 10 to 18 cm in height at the time of application. Common lambsquarters control and density reduction were not influenced by the time of day. 2,4-D provided the least control and density reduction of the tested herbicide treatments on common lambsquarters. Waterhemp control and density reduction were influenced by both herbicide treatment and time of day. Control and density reduction were greater during the day compared with the night application. Herbicide mixtures were more effective than singular applied herbicides for waterhemp. Soybean yield was not different across all tested herbicide treatments. The results of the experiment provide evidence that waterhemp is more influenced by application time-of-day compared with common lambsquarters with 2,4-D and glufosinate applied alone and in mixture. Therefore, these herbicide treatments should be applied during the day to achieve efficacy. While yield was not decreased with singular herbicide applications, mixtures of these herbicides should be used for more effective weed management.

65 - Atrazine Alternative PSII- and HPPD-Inhibitor Tank Mixes for Improved Weed Control in Wisconsin Corn Production Systems

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In Wisconsin, the added challenge of atrazine prohibition zones puts additional selection pressure on HPPD-inhibitors (i.e., mesotrione) for control of challenging weeds such as waterhemp (*Amaranthus tuberculatus*) and giant ragweed (*Ambrosia trifida*) in corn production systems. Due to a known synergism between PSII- and HPPD-inhibitors, tank mixtures containing both modes of action show enhanced control, consistency, and resistance management characteristics. However, without atrazine in such areas, weed control options are limited leading to a need to revisit other PSII-inhibitor tank mixture partners. Thus, this study was conducted to evaluate control of waterhemp and giant ragweed by tank mixing atrazine alternative PSII- and HPPD-inhibitors to protect the effectiveness of the latter site of action group and provide research-based weed management recommendations to Wisconsin corn growers farming in atrazine prohibition areas. A field experiment following a randomized complete block design with four replications in 2024 and 2025 at two locations with confirmed triazine-resistant and low level mesotrione-resistant waterhemp (Brooklyn, WI) and suspected glyphosate- and low level mesotrione-resistant giant ragweed (Janesville, WI). At each site, three PSII-inhibitors (metribuzin at 210 g ai ha^{-1}, bentazon at 842 g ai ha^{-1}, and bromoxynil at 280 g ai ha^{-1}) and two HPPD-inhibitors (mesotrione at 106 g ai ha^{-1} and topramezone at 18 g ai ha^{-1}) were applied either solo or tank-mixed when target weeds were approximately 10 cm tall. Crop injury (%) was evaluated 14 days after treatment (DAT), visual weed control estimates (%) were evaluated 28 DAT, and grain yield (kg ha^{-1}) at the end of the season. We found that tank mixing PSII- and HPPD-inhibitors enhanced weed control compared to herbicides alone at both sites. Mesotrione alone controlled waterhemp by 65% which increased to 98% and 93% when metribuzin and bromoxynil were mixed, respectively. Other mixtures ranged from 53 to 80% for waterhemp control. Both topramezone and mesotrione alone controlled giant ragweed by 84 and 56%, respectively; addition of bentazon or bromoxynil to each HPPD-inhibitor increased control, ranging from 87 to 93%. Other tank mix combinations ranged from 74 to 85% for control of giant ragweed. Corn injury was dependent on the PSII-inhibitor. At both sites, regardless of tank mixing HPPD-inhibitors, corn injury ranged from 19 to 23% for metribuzin, 9 to 11% for bromoxynil, and 1 to 4% for bentazon. Of the herbicide treatments that were highlighted above with the best weed control at each site (>85%), yield was comparable to the weed-free check. Bromoxynil + mesotrione (12,393 kg ha^{-1}) and metribuzin + mesotrione (12,299 kg ha^{-1}) had similar yield compared to the weed-free check (12,306 kg ha^{-1}) while providing >90% waterhemp control. Bromoxynil + HPPD-inhibitor and bentazon + HPPD-inhibitor treatments protected the most average yield ranging from 12,840 to 13,588 kg ha^{-1}, compared to the weed free check (14,341 kg ha^{-1}) while providing the most giant ragweed control (>85%). These results provide growers in atrazine prohibition areas with potentially effective POST herbicide treatments utilizing atrazine alternative PSII- and HPPD-inhibitors synergistic tank mixtures for control of troublesome broadleaf weeds in Wisconsin corn production.

66 - Surtain Herbicide: Label Expansion for Weed Management in Popcorn and Processing Sweet Corn

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Surtain™ herbicide is a novel formulation that was commercially introduced by BASF in 2025 season offering a broad-spectrum residual premix with PRE and POST flexibility in Field corn. BASF plans to expand Surtain™ herbicide label in Popcorn and Processing sweet corn. Surtain™ herbicide is a premix of saflufenacil (capsulated) and pyroxasulfone. This combination gives Surtain™ herbicide remarkable residual endurance which delivers long-lasting activity on numerous small and large seeded broadleaf weeds and grasses. The combination of group 14 and 15 herbicides in Surtain™ herbicide delivers excellent residual activity on herbicide-resistant weeds, including HPPD-resistant Amaranthus spp. The unique solid encapsulation technology enables the POST application of PPO chemistry (saflufenacil) in corn with reliable crop safety. Surtain™ herbicide can be applied as Preplant, Preemergence, and Early-Postemergence up to V3 stage of corn. Surtain™ herbicide is expected to be launched in popcorn and processing sweet corn market for use in the 2027 season.

67 - Soybean Planting Date and Metribuzin Rate on Waterhemp Control, Crop Injury and Yield

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Waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] is one of the most troublesome weeds in Ohio, due to its prolonged emergence window, prolific seed production, and continued development of herbicide resistance. Metribuzin, when used as a pre-emergence (PRE) herbicide, has shown to be effective for control of small, seeded broadleaves, such as waterhemp. Despite metribuzin's known efficacy, farmers may be reluctant to use it due to crop injury concerns. A field study was conducted in 2025 in South Charleston, OH to evaluate metribuzin rates as part of comprehensive herbicide programs to maximize waterhemp control and minimize crop injury in early and normal planted soybeans (*Glycine max* L.). The two factors in this study were: 1) herbicide (flumioxazin + pyroxasulfone, flumioxazin + pyroxasulfone + metribuzin at 0.13, 0.42, 0.63, or 0.84 kg ai ha^{-1}, sulfentrazone, and metribuzin + sulfentrazone) and 2) soybean planting date (early and normal). This study was conducted as a fully factorial split-plot randomized complete block design with 16 treatments and 4 replications. Seven days after soybean emergence (DAE), soybean necrosis was higher in the later planting date relative to the early planting date. Within the normal planting date, flumioxazin + pyroxasulfone + 0.84 kg ai ha^{-1} metribuzin had the highest necrosis, the untreated check (UTC) the lowest, and no significant treatment differences occurred among the remaining treatments. Soybean necrosis did not differ among planting date or herbicide treatments at later measurement evaluation timings, indicating that the plants outgrew the damage. Differences in soybean stunting among herbicide treatments were observed at 7 and 28 DAE, and at the time of the post application. At 14 DAE, significant differences occurred in the planting date x herbicide interaction. Across all measurement timings, treatments with sulfentrazone consistently caused the greatest soybean stunting. At 14 DAE, all treatments where a herbicide was applied provided similar waterhemp control, from (97-100%). Waterhemp control was consistent across 28 DAE and the POST application timing for most herbicides with flumioxazin + pyroxasulfone + 0.42, 0.63, or 0.84 kg ai ha^{-1} metribuzin achieving nearly 100% control across planting dates. Flumioxazin + pyroxasulfone + 0.13 kg ai ha^{-1} metribuzin (63%) and UTC (20%) being the least effective. Early planting generally increased soybean yields relative to the later planting date. Within the early planting date, flumioxazin + pyroxasulfone + 0.13, 0.63 kg ai ha^{-1} metribuzin produced the highest yields. In contrast, the untreated check under normal planting had the lowest yield. This data suggests that early planting increased soybean yield. Stunting and necrosis from treatments with sulfentrazone declined throughout the growing season and did not influence yield. Waterhemp management benefits from the addition of metribuzin, in terms of control as well as diversifying effective sites-of-action. This study emphasizes the impact of planting date and herbicide choice on both soybean performance and weed management.

68 - Confirmation of Multiple Herbicide-Resistant Kochia in South Dakota

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Kochia (*Bassia scoparia* L.) is one of the most troublesome summer annual broadleaf weeds in the Great Plains. Greenhouse experiments were conducted at South Dakota State University, Brookings, SD in 2025, to screen four kochia populations for herbicide resistance to field-use rates of atrazine, bromoxynil, dicamba, fluroxypyr, glufosinate, glyphosate, imazamox, lactofen, mesotrione (at half the field-use rate), and saflufenacil. Three putative resistant kochia populations were collected from Codington, Hughes, and Spink Counties in 2023 and 2024, and one susceptible population was collected from Clay County, SD, in 2015. The Spink County population showed only 32% injury to glyphosate, 10% to imazamox, and 25% to saflufenacil, all of which were significantly lower than the injuries observed in the susceptible population. The Hughes County population showed only 34% injury to imazamox and 55% to saflufenacil. The Codington County population showed only 35% injury to glyphosate and 51% to imazamox. Similarly, for biomass reduction, the Spink County population exhibited only 50% reduction compared to the non-treated control with glyphosate, 12% with imazamox, and 58% with saflufenacil, indicating multiple herbicide resistance. A separate saflufenacil dose-response experiment was conducted using a completely randomized design with five replications and two experimental runs with all four populations. Herbicide rates were 0, 2.5, 7.9, 25 (field-use rate), 79, 250, and 2500 g ai ha^{-1} with COC at 1% v v^{-1}. The Spink County population exhibited less than 5% injury at all tested saflufenacil rates. The ED_{50} values for the Clay, Codington, and Hughes County populations were similar (9 to 12 g ai ha^{-1}). However, the Hughes County population never incurred injury greater than 70%, while the ED_{80} values for the Clay and Codington County populations were 50 and 56 g ai ha^{-1}, respectively. The results of both experiments indicate that the Spink County population is three-way resistant (glyphosate, imazamox, and saflufenacil). These results also suggest that the Hughes County population is likely resistant to imazamox and saflufenacil, and the Codington County population is likely resistant to glyphosate and imazamox.

69 - Evaluation of Corn Herbicide Tank-Mixes for Postemergence Control of Summer Annual Grasses in Glyphosate- and Atrazine- Restricted Systems

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Wisconsin corn (*Zea mays*) growers face unique challenges in their weed control programs. Managing weeds is not a one size fits all solution, whereas hurdles such as atrazine prohibition areas, glyphosate-resistant weeds, and/or cultivation of non-GMO corn hybrids result in the loss of commonly used herbicides such as atrazine and/or glyphosate. In a recent survey of Wisconsin corn growers, giant foxtail (*Setaria faberi*), fall panicum (*Panicum dichotomiflorum*), wooly cupgrass (*Eriochloa villosa*), barnyardgrass (*Echinochloa crus-galli*), and wild proso millet (*Panicum miliaceum*) were ranked as five of their top ten most difficult to control weeds. These species are highly competitive and can cause major corn yield loss if uncontrolled. Thus, the goal of this greenhouse study was to evaluate the efficacy of 5 POST herbicides applied alone or in tank mixture on the 5 previously mentioned summer annual grass species. The herbicides evaluated were glyphosate (840 g ai ha-1), nicosulfuron (34 g ai ha-1), mesotrione (105 g ai ha-1), atrazine (560 g ai ha-1), and bromoxynil (280 g ai ha-1). Herein, glyphosate and nicosulfuron are treated as herbicides with known grass activity (hereafter referred to as "grass" herbicides), whereas atrazine, mesotrione, and bromoxynil are known to have little to no grass activity but can enhance the activity of tank mix partners, thus classified as "broadleaf" herbicides. Treatments consisted of two broadleaf herbicides, one grass and one broadleaf herbicide, and one grass and two broadleaf herbicides, plus each herbicide alone, for a total of 17 herbicide treatments plus a non-treated

control, applied across 5 grass species. The greenhouse maintained a simulated 16-hour photoperiod, and plants were watered to field capacity daily with a 10-20-20 complete liquid fertilizer applied via fertigation weekly. When the plants reached 15 cm in height, they were sprayed with a single-nozzle research track spray chamber using an AI9502EVS nozzle calibrated to deliver a carrier volume of 140 L ha−1 of spray solution at 276 kPa. Plant biomass was collected 21 days after herbicide application, dried, and the reduction in biomass compared to the non-treated check was estimated and used as an indicator of weed control. Treatment efficacy varied across species. Overall, the best control was observed when a grass herbicide and a broadleaf herbicide or a grass herbicide and 2 broadleaf herbicides were applied, showing the value of tank mixing. Specifically, nicosulfuron + atrazine (85% biomass reduction) and nicosulfuron + bromoxynil (87% biomass reduction) were the best treatments overall across all five species. This research provides growers with additional options when choosing their herbicide program. For growers, understanding what tank mixes work best when and having the research backing alternative tank mixes gives them the flexibility needed to meet their grass control needs across Wisconsin corn systems, where atrazine and or glyphosate may not be viable options.

70 - Spring Oats and Weedy Grass Herbicides

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Farmers struggle to control weedy annual grasses in spring oat (*Avena sativa*) production fields. In the Mid-Atlantic and Upper Midwest regions there are no herbicides that are labeled for use in oats that will provide consistent control of a variety of summer annual grassy weeds such as giant and yellow foxtail (*Setaria faberi* and *pumila*), large crabgrass (*Digitaria sanguinalis*), and fall panicum (*Panicum dichotomiflorum*). Field studies were conducted at Penn State and Michigan State Universities in 2025 to investigate spring oat safety and giant foxtail control with various herbicides at different application timings. The study was a RCBD with 3-replications and plots that measured 3 x 8 m. Oats were planted in early/mid-April into a tilled seedbed. Herbicides were applied with a small-plot sprayer system thru TeeJet AIXR nozzles. Herbicides included: pendimethalin (1065 g ai ha-1), pyroxasulfone (110 g), s-metolachlor (1065 g), diuron (1345 g), bicyclopyrone (51 g), and tolpyralate (33 g). Depending on the herbicide, treatments were applied as DPRE (5-7 DAP), EPOST (1-2 leaf oats), and/or POST (20-25 cm oats; weeds 2-5 cm). Visual crop injury and giant foxtail control ratings were collected routinely during the season. Across both locations, data showed that pendimethalin applied either DPRE or EPOST caused 2-12% oats injury and 77-100% giant foxtail control at mid and late season ratings; pyroxasulfone caused 33-75% oats injury when applied either DPRE or EPOST and 68-99% foxtail control; s-metolachlor caused 0-13% oats injury and 87-100% foxtail control when applied either DPRE or EPOST; diuron applied at all timings caused 0-11% oats injury and 53-99% foxtail control; bicyclopyrone applied at either EPOST or POST caused 0-35% oats injury and 57-83% foxtail control; and tolpyralate applied at either EPOST or POST caused 0-9% oats injury and 27-84% foxtail control. In summary, results indicate that there are herbicides that only cause minimal injury to spring oats yet provide adequate control of giant foxtail (and other weedy grasses). Potential herbicide candidates include pendimethalin, s-metolachlor, and diuron since both crop safety and weed control were acceptable. Although, bicyclopyrone and tolpyralate exhibited minimal crop injury by late season, their weed control was generally inadequate. In these and previous other studies, pyroxasulfone caused significant oat injury thus it is likely not a viable option. Also, in prior studies at Penn State, when applied POST, pyroxsulam caused 50-65% oat injury while mesosulfuron caused 65-98% injury, thus disqualifying them as choices. Manufactures of these viable herbicide candidates should consider adding spring oat to their respective labels for use in the Eastern and Midwestern regions of the U.S.

71 - Investigation of Pyridate and HPPD-Inhibitor Mixtures in a Controlled Environment

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Herbicide applications with multiple effective modes of action enhance efficacy while broadening the spectrum of weed control for both monocot and dicot weed species. Prior research has characterized the synergistic interaction between photosystem II (PSII) inhibitors, such as atrazine, and 4-hydroxyphenylpyruvate dioxygenase (HPPD) inhibitors, like mesotrione. Pyridate (HRAC Group 6) is a PSII-inhibitor but binds at a distinct site, Histidine 215 on the D1 protein, unlike atrazine which binds to Serine 264. Previous field experiments have suggested that the co-application of pyridate with HPPD-inhibitors will result in additive and synergistic herbicide interactions applied postemergence. The current study was designed to confirm these interactions in a controlled environment by characterizing the effects of herbicide mixtures comprising pyridate, mesotrione, and tembotrione on three prominent weed species: waterhemp (*Amaranthus tuberculatus* [Moq.] J. D. Sauer), Palmer amaranth (*Amaranthus palmeri* S. Watson), and large crabgrass (*Digitaria sanguinalis* [L.] Scop.). The herbicide treatments included a nontreated control, individual applications of pyridate, mesotrione, and tembotrione, and combinations of pyridate with mesotrione and pyridate with tembotrione. Both herbicide combinations resulted in synergistic weed control at 7 and 14 days after herbicide application across all weed species. These findings have important implications for agricultural practices, particularly in corn production, as the synergistic interactions among these herbicides may enhance control of troublesome weeds. Furthermore, this approach offers a strategic advantage in mitigating the risk of herbicide resistance by employing multiple effective modes of action within a single application. Future research will explore the underlying biochemical mechanisms of the observed synergy between PSII- and HPPD-inhibitors, aiming to improve our understanding of these interactions through detailed biochemical pathway analyses.

72 - Relative Volatility of Amicarbazone, Atrazine, and Metribuzin Under Lab Conditions

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Herbicide dissipation is a complex process where each individual scenario is governed by unique set of conditions that will determine the most important loss mechanism for that individual situation. Volatilization can be a critical pathway for herbicide loss from agricultural fields with results being possible reduced herbicide efficacy and possible non-target effects in the environment.

A laboratory study was conducted to examine the relative volatility of amicarbazone, atrazine, and metribuzin when applied to dry soil. Doses of all herbicides were the standard labeled rate (SLR) for a medium soil. The study was conducted using previously published humidome methods (Mueller previous reports). The two types of sampling media included a “filter paper” followed by a Polyurethane Foam plug (PUF). Two greenhouse runs were conducted across two different years.

Apparent amicarbazone emissions were substantially lower than metribuzin and atrazine in this test system. When compared at the SLR, apparent emissions collected on the filter paper for metribuzin and atrazine were ~ 130 and 210% compared to amicarbazone. The results from the PUF samplers were even more disparate, with amicarbazone being just above the limit of detection, but the other 2 herbicides showing several orders of magnitude greater herbicide concentrations.

73 - Pre-Emerge Herbicide Affect on Iron Deficiency Chlorosis Severity in Different Soybean Cultivars

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Iron deficiency chlorosis (IDC) is a significant problem in high pH calcareous soils found in the upper Midwest that affects susceptible species of plants including soybean [*Glycine max* (L.) Merr]. This nutrient deficiency can be a major yield reducing factor in this region resulting in an average yield loss of 0.8 Mg ha^{-1}. Several factors can influence the presence of IDC including high carbonate/bicarbonate levels, soluble salts, soil pH, nitrate levels, soil moisture, and environmental stressors. Herbicides can also cause injury stress to soybean leaving the plant more susceptible to pests and deficiencies. Preemergent residual herbicides are becoming more important among the increasing soybean acres in the upper Midwest to ensure proper weed control. It is important to understand if certain residual herbicides can increase IDC severity in conducive soils. The objective of this study is to determine the impact of residual herbicides on the severity of IDC. This experiment was a RCBD with four replications conducted as a 2x2x9 factorial arrangement with the factors being soil type, soybean cultivar, and herbicide, respectfully. A fine soil and coarse soil were collected for the soil types. Each location where the soil was collected has a history of IDC with the pH ranging from 8.3-8.5. The fine soil was collected near Barnesville, Mn and the coarse soil was collected in Glyndon, Mn. An IDC susceptible and tolerant cultivar was used in the experiment. The herbicide used in the experiment was a commercial premixture containing saflufenacil & imazethapyr & pyroxasulfone, was applied at two rates, representing 1X use rates in the northern and southern part of the geography. The individual active ingredients were also applied as separate treatments, resulting in eight herbicide treatments, plus a non-treated control. Data was collected using NDSU’s IDC visible rating scale (1-5) as well as using a SPAD meter (Soil and Plant Analysis Development) which is used to determine chlorophyll content in plant tissue. When comparing factors, each evaluation timing had different factor interactions. At the peak of IDC occurrence, all three factors had interactions with each other. In regards to the SPAD chlorophyll measurements, the fine textured soil was significantly lower than the coarse soil and the tolerant varieties were significantly higher than the susceptible varieties. For soil ^{x} variety, the fine soil/susceptible variety had significantly less chlorophyl than the other soil ^{x} varieties. The lower rates of the premixture and saflufenacil had significantly less chlorophyll than the check and low rate of pyroxasulfone for variety ^{x} herbicide. The fine soil with the low rate of the premixture and both rates of saflufenacil resulted in the lowest chlorophyll measurements across soil ^{x} variety ^{x} herbicide. This experiment shows that preemergence herbicides can influence IDC severity along with soil type and variety choice. It is still greatly important to select tolerant soybean varieties and soil test often to mitigate IDC severity. Herbicide choice may be a consideration for prevention of enhancing the severity of IDC in highly calcareous soils, however, further research is needed to confirm these results.

74 - Resicore® Rev: The Foundational Choice for Weed Control in Corn

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Resicore® REV herbicide is a formulation developed by Corteva Agriscience that contains encapsulated acetochlor, mesotrione, and clopyralid plus a crop safener for preemergence and postemergence weed control in a two-pass corn herbicide program. Resicore REV herbicide may be used preplant, preemergence (after planting but prior to crop emergence), or postemergence (after crop emergence, up to 24 inches tall) in field corn, field seed corn, and field silage corn fields. For yellow popcorn, Resicore REV must be applied prior to crop emergence. For broad-spectrum postemergence control in the Midwest and Southern corn growing areas of the US, the recommendation is to tank mix Resicore REV with other herbicides such as glyphosate and atrazine. Results from over 30 Corteva Agriscience research trials conducted from 2024 to 2025 have shown Resicore REV to have excellent crop safety, with <10% crop response observed with POST applications at highest recommended label rates when tank-mixed with glyphosate, atrazine, and non-ionic surfactant. The three proven modes of action in Resicore REV combat the progression of herbicide resistance and provide residual control on broadleaf and grass weeds in corn. Additionally, results from trials have shown Resicore REV followed by tank mixtures of Resicore REV plus glyphosate plus atrazine plus crop oil concentrate provided >90% POST control at four weeks after application of many key weeds, including giant ragweed (*Ambrosia trifida*), common waterhemp (*Amaranthus rudis*), Palmer amaranth (*Amaranthus palmeri*), common lambsquarters (*Chenopodium album*), and annual grasses across the Midwest and Southern United States. Resicore REV also demonstrates improved mixing and handling characteristics allowing for ease of use over wide temperature ranges and outstanding tank-mix compatibility with fungicides, insecticides, foliar fertilizers and/or micro-nutrients.

75 - Timing of Overlapping Residual Herbicide Applications in Corn

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Residual herbicides are essential for successful weed management. They reduce reliance on postemergence herbicides, thereby improving weed management outcomes and reducing selection pressure for herbicide-resistant weed populations. This study aimed to evaluate the influence of overlapping residual herbicide application timings on weed control in corn (*Zea mays* L.). A field experiment was conducted in 2025 at the Ashland Bottoms Research Farm near Manhattan, KS in a randomized complete block design with four replications. Treatments consisted of S-metolachlor + atrazine + mesotrione + bicyclopyrone (0.90 + 0.42 + 0.10 + 0.025 kg a.i ha^{-1}) preemergence (PRE), followed by an overlapping residual application at 14, 21, 28, 35, and 42 days after PRE (DAP). One treatment with a single application of 1.8 + 0.84 + 0.20 + 0.050 kg a.i ha^{-1} was included. Visible weed control was recorded at the time of the overlapping residual application and 28 and 42 days after the last application using a scale of 0% (no control) to 100% (complete control). Corn grain yield was recorded at harvest and adjusted to 15.5% moisture. Data were subjected to analysis of variance (ANOVA), and means were separated using Tukey's HSD test ($\alpha = 0.05$). Treatments that included overlapping residual applications had greater weed control 42 DAP. *A. palmeri* control was 58% following the PRE application, whereas overlapping applications between 14 and 35 DAP maintained control greater than 90%. Similarly, *I. hederacea* control was greater than 95% in overlapping programs but dropped to 73%. Corn grain yield followed similar trends to weed control. The single PRE treatment yielded the least, 3.138 kg ha^{-1}. Overlapping residual application 35 DAP resulted in the greatest yield, 7.217 kg ha^{-1}, representing more than a 100% increase compared to the PRE-only program. Overall, overlapping residual herbicide applications made between 21 and 42 DAP maintained yield greater than 5.648 kg ha^{-1}, reinforcing that overlapping residual herbicide applications can maximize weed control and corn yield.

76 - Postemergence Herbicides for the Control of Multiple-Herbicide-Resistant Canada Fleabane in Corn

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Multiple-herbicide-resistant (MHR) Canada fleabane [*Conyza canadensis* (L.) Cronq.] control has become a major concern for corn producers in Ontario. Postemergence (POST) herbicides are critical for the control of emerged MHR Canada fleabane in corn. A study that consisted of five field experiments was conducted in southwestern Ontario in fields with confirmed MHR Canada fleabane to evaluate various herbicide mixtures applied POST for the control of MHR Canada fleabane in corn. Glyphosate + 2,4-D amine, glyphosate/2,4-D choline, glyphosate + clopyralid, glyphosate + *S*-metolachlor/mesotrione/bicyclopyrone, glyphosate + tolpyralate + atrazine, glyphosate + dicamba, glyphosate + dicamba/atrazine, glyphosate + *S*-metolachlor/mesotrione/atrazine, glyphosate + mesotrione + atrazine, glyphosate + bromoxynil + atrazine, glyphosate + *S*-metolachlor/mesotrione/bicyclopyrone/atrazine, glyphosate/*S*-metolachlor/mesotrione + atrazine, glyphosate/dicamba + tembotrione, glyphosate + tembotrione + bromoxynil, glyphosate/dicamba + tembotrione + atrazine, and glyphosate + tembotrione + atrazine applied POST provided 63-99% control, 77-100% density reduction, and 88-100% shoot biomass reduction of MHR Canada fleabane in corn. MHR Canada fleabane interference reduced corn yield up to 58%; reduced MHR Canada fleabane interference with all herbicide treatments resulted in corn yield similar to the weed-free control. Results of

this study indicate that among the herbicide mixtures evaluated glyphosate + mesotrione + atrazine, glyphosate + bromoxynil + atrazine, glyphosate + *S*-metolachlor/mesotrione/bicyclopyrone/atrazine, glyphosate/*S*-metolachlor/mesotrione + atrazine, glyphosate/dicamba + tembotrione, glyphosate + tembotrione + bromoxynil, glyphosate/dicamba + tembotrione + atrazine, and glyphosate + tembotrione + atrazine applied POST provided the most consistent control of MHR Canada fleabane in corn.

77 - Emergence Timing of Shattercane (*Sorghum bicolor* L.) and Implications for Management in Corn

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Shattercane *(Sorghum bicolor L.)* is a troublesome weed in corn and sorghum production systems due to its competitive growth and the limited spectrum of herbicides available for its control. In recent years, observations of seeding shattercane on the edges of corn fields throughout Missouri have increased. Previous studies show plants do not exhibit herbicide resistance; suggesting variable emergence timing may contribute to late-season infestations. Field studies in infested areas were conducted near Columbia and Williamsburg, Missouri, in 2025 to characterize seasonal shattercane emergence patterns. Following conventional tillage, emergence was monitored weekly within five, fixed 0.25 m^2 quadrats per site from May through August, with seedlings removed after each count. Concurrently, hourly environmental data (e.g. soil temperature, precipitation) were collected to support predictive modeling of emergence timing. Although emergence began and ended at approximately the same calendar time at both sites (23 May to 29 August), the periodicity and magnitude of emergence differed. Columbia exhibited an earlier and more concentrated peak (13 June; 47 seedlings per 0.25 m^2) as well as greater cumulative emergence (1,108 plants), while Williamsburg peaked later (20 June; 36 seedlings per 0.25 m^2) with less cumulative emergence (711 plants). Peaks were determined based on the highest average number of seedlings emerged across quadrants during a given sampling week. Columbia's sharp, early peak corresponded with warm soil temperatures and early-season rainfall, while Williamsburg exhibited slower, prolonged emergence under cooler, drier conditions. Roughly 50% of seasonal emergence occurred by mid- to late June, suggesting that significant shattercane emergence continues beyond the typical last herbicide application window in corn. Late-season shattercane infestations may therefore arise from delayed emergence in areas where the corn canopy does not fully close.

78 - Winter wheat tolerance to clopyralid applied in the fall, spring, or fall followed by spring

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Limited information exists on the sensitivity of winter wheat to clopyralid applied in the fall, spring, or sequentially [fall followed by (fb) spring] under Ontario environmental conditions. Six field experiments were conducted over two years (2023 and 2024) near Exeter and Ridgetown, Ontario, to evaluate the

effects of clopyralid (100, 200, and 400 g ai ha^{-1}) applied in the fall, spring, or sequentially (fall fb spring) on winter wheat injury, height, seed moisture content, and yield. No visible injury was observed at 1, 2, and 4 weeks after application with clopyralid applied in the fall, spring, or sequentially at the evaluated rates. Clopyralid applied in the fall at all rates caused no injury to winter wheat; in contrast, when applied in the spring clopyralid caused 3, 7, and 14% visible injury at 100, 200, and 400 g ai ha^{-1}, respectively. Sequential applications of clopyralid (fall fb spring) resulted in 4, 9, and 17% visible injury at the same respective rates. Clopyralid application at 100, 200, and 400 g ai ha^{-1} in the fall, spring, or sequentially had no significant effect on winter wheat height or seed moisture content. Clopyralid applied at 100, 200, and 400 g ai ha^{-1} in the fall did not affect winter wheat yield. Clopyralid applied at 100 and 200 g ai ha^{-1} in the spring had no impact on yield, but when applied at 400 g ai ha^{-1}, it reduced winter wheat yield by 19%. Sequential applications at 100 fb 100 and 200 fb 200 g ai ha^{-1} also had no significant effect on winter wheat yield, while the 400 fb 400 g ai ha^{-1} treatment reduced winter wheat yield by 17%. These results suggest that clopyralid applied in the fall caused no visible wheat injury and no decrease in wheat height or yield. Clopyralid, applied in the spring at 100 and 200 g ai ha^{-1} caused 3 and 7% visible wheat injury, respectively but no decrease in wheat height or yield. Clopyralid applied in the spring at 400 g ai ha^{-1} caused up to 19% visible wheat injury and reduced wheat yield by up to 17%. These results conclude that clopyralid at the label rate applied in the fall, spring, or sequentially has no adverse effect on winter wheat; however, where there is a spray overlap clopyralid can cause unacceptable wheat injury and yield loss.

79 - Evaluation of Multiple Two-Way Herbicide Tank Mixes to Support Effective Postemergence Waterhemp Control in Wisconsin

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The proliferation of herbicide resistance in waterhemp (*Amaranthus tuberculatus*) combined with new developments in soybean (*Glycine max*) herbicide resistance traits continue to alter the chemical weed control landscape. The objective of this study was to investigate whether two-way combinations are more effective than single active ingredient solutions and to discover which programs provide effective postemergence (POST) control of waterhemp. The study focused on herbicides currently labeled in soybean and herbicide options that will become labeled through novel traits (e.g., mesotrione on Vyconic soybean) totaling 10 different active ingredients from 7 sites of action (chlorimuron, cloransulam, imazethapyr, 2,4-D, bentazon, glyphosate, glufosinate, fomesafen, lactofen, and mesotrione) applied at label rates. Treatments were applied using distilled water as the carrier without the addition of AMS or adjuvants. Waterhemp accessions studied included A106, A125, and A133, which were collected from different locations in southern Wisconsin. Waterhemp plants were sprayed at 10 cm height using a research spray chamber that delivered 15 L ha^{-1} with an AI 09502 nozzle. At 21 days after treatment (DAT), visual control assessment and mortality data were recorded; plants were then harvested and dried to constant weight to obtain biomass reduction data. Twenty out of fifty-five treatments provided effective visual control (≥90% visual control). Out of twenty treatments with effective control, two were single products (2,4-D, glufosinate) and eighteen were two-way mixtures, seventeen mixtures containing either

2,4-D or glufosinate. Overall, 2,4-D and glufosinate-containing treatments provided effective control whereas bentazon reduced control of multiple tank mix partners. Mesotrione mixed with lactofen, glyphosate, fomesafen, 2,4-D, and glufosinate provided >90% control. These results are indicative of promising future mixtures that are capable of providing effective waterhemp control based on current and novel herbicide resistance traits, including mesotrione in soybean.

80 - Utilizing Epyrifenacil (Rapidicil®) for Termination of a Failed Stand of Corn

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Planting dates have continued to shift earlier into the spring, increasing the chance of sub-optimal plant populations requiring growers to terminate and replant. Currently there are very few effective termination options for a failed stand of corn (*Zea mays* L.) that does not require lengthy plant back restrictions. Options for successful corn termination are limited due to herbicide tolerance traits, lack of complete control, or lengthy plant-back restrictions. Rapidicil® (epyrifenacil) is a novel, fast-acting PPO-inhibitor currently being developed by Valent U.S.A. LLC for preplant burndown uses in corn, soybean, wheat, and non-crop areas/industrial vegetation management. *Rapidicil* has shown efficacy in controlling volunteer crops, including a failed stand of corn, with a proposed one-day plant back restriction. In 2025, an experiment evaluating *Rapidicil* as a failed stand termination option was conducted across three locations. Corn ranged from V2-V4 growth stage at the time of application and was subsequently replanted approximately one day later. Treatments included: epyrifenacil (*Rapidicil*) at 10 and 20 g ai ha^{-1} with various tank mixes including glyphosate and/or 2,4-D. Additionally, clethodim at 52.5 g ai ha^{-1} and saflufenacil at 25 g ai ha^{-1} were included as comparison treatments. *Rapidicil* treatments were effective at controlling a failed stand of corn with >96% control at 3 days after treatment (DAT), while clethodim did not provide effective termination (95%) until 14 DAT. Saflufenacil was ineffective at controlling the failed stand through 28 DAT. The speed of termination and a flexible plant back restriction of one day in corn will allow *Rapidicil* to be effectively used to reach optimal corn populations and ultimately increase yields. *Rapidicil* is currently pending EPA registration and is not available for sale.

81 - Effect of Overlapping Residual Herbicide Program on Seed Production of Palmer Amaranth in Irrigated Sorghum (*Sorghum bicolor* (L.) Moench)).

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Grain sorghum (*Sorghum bicolor (L.) Moench*) is the sixth-largest row crop in the United States; however, weed management is very challenging because of limited herbicides. A growing number of weeds have evolved resistance to multiple sites of action, complicating management; the feasibility of an overlapping herbicide program for weed control was evaluated to manage HR Palmer amaranth (*Amaranthus palmeri S. Watson*) and giant foxtail (*Setaria faberi Herrm*). The objective of this study is to evaluate the effectiveness of very-long-chain fatty acid-inhibiting herbicide programs with different active ingredients on Palmer amaranth seed production, Palmer control, and giant foxtail control. A field experiment was conducted using a split-plot design with three replicates in which two pre-emergence (PRE)-only treatments were main plots, and combinations of early post-emergence (EPOST) and late post-emergence (LPOST) herbicide programs at different rates, including a weed-free, non-treated control, were subplots for comparison. Significant interactions were observed between PRE and POST herbicide programs for Palmer amaranth count, Palmer visual rating, and foxtail count and visual rating. Under PRE (mesotrione + S-metolachlor, 0.18+1.78 kg ai ha^{-1}), sequential application of EPOST (acetochlor, 2.52 kg ai ha^{-1} at V2; 6to7 inch tall) fb LPOST (dimethenamid-P, 0.95 kg ai ha^{-1} at V5-V6; 11 inch tall) provided the greatest Palmer amaranth suppression, reducing Palmer count by 87.5% and visual ratings by 82% compared to the non-treated control. With PRE (atrazine + mesotrione + S-metolachlor, 1.46+0.19+1.46 kg ai ha^{-1}), the same sequential POST application achieved 85% reduction in Palmer amaranth count and 78% reduction in visual rating. PRE-only programs resulted lower efficacy; PRE (mesotrione + S-metolachlor) alone provided 48% control,PRE (atrazine + mesotrione + S-metolachlor) alone achieved 53% control, highlighting the importance of overlapping residual applications. Neither low nor high level of Palmer amaranth control was observed with EPOST (acetochlor, 2.52 kg ai ha^{-1}at V2; 6to7 inch tall) fb LPOST (dimethenamid-P, 0.95kg ai ha^{-1}at V5-V6; 11 inch tall), which reduced Palmer amaranth count by 65-75% depending on PRE treatment. Palmer amaranth seedbank density at harvest was reduced from >220 seeds·m^{-2} in control plots to <25 seeds·m^{-2} (>90% reduction) in treatments combining PRE with EPOST (acetochlor, 3 kg ai ha^{-1}at V2; 6to7 inch tall) fb LPOST (dimethenamid-P, 0.95 kg ai ha^{-1}at V5-V6; 11 inch tall). Foxtail suppression was less responsive to sequential herbicide applications. PRE (mesotrione + S-metolachlor, 0.18+1.78 kg ai ha^{-1}) combined with POST sequences resulted in 60% foxtail count reduction, while PRE (atrazine + mesotrione + S-metolachlor) fb POST sequences resulted in 58% foxtail count reduction. Visual ratings followed similar trends. Results demonstrate that overlapping residual herbicide programs significantly improved Palmer amaranth suppression and seedbank reduction compared to PRE-only applications. The most effective programs combined EPOST (acetochlor, 2.52 kg ai ha^{-1}at V2; 6to7 inch tall) fb LPOST (dimethenamid-P, 0.95 kg ai ha^{-1}at V5-V6; 11 inch tall) regardless of PRE herbicide type. Although foxtail suppression remained moderate, overlapping PRE fb sequential POST herbicide treatments provided substantial improvement in Palmer seed bank control and Palmer density control compared to PRE-only programs in grain sorghum production.

82 - Tank-Mix of HPPD and PSII Inhibitor Herbicides for Postemergence Control of HPPD-Resistant Waterhemp

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Waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] is among the most challenging weeds to manage in U.S. seed corn production due to its extended emergence window, prolific seed production, and widespread evolution of resistance to multiple herbicide modes of action. In recent years, waterhemp populations resistant to postemergence (POST) applications of photosystem II (PSII)- and 4-hydroxyphenylpyruvate dioxygenase (HPPD)-inhibitor herbicides have been reported in continuous seed corn production fields in Iowa. Several studies have demonstrated that tank mixing HPPD with PSII inhibitors herbicides provided synergistic effect for control of several weed species. However, limited information exists on their interaction for POST control of HPPD-resistant waterhemp in seed corn systems. Field research was conducted in 2024 in a seed corn production field near McCallsburg, Iowa, where waterhemp had survived PRE applications of HPPD-inhibiting herbicides. The experiment was arranged as a randomized complete block design with four replications. Treatments included mesotrione (HPPD-inhibitor) at 105 g ha^{-1} and four PSII-inhibitor herbicides: atrazine (1,121 g ha^{-1}), metribuzin (79 g ha^{-1}), pyridate (350 g ha^{-1}), or bromoxynil (280 g ha^{-1}). Each herbicide was applied alone, and each PSII-inhibitor was also tank-mixed with mesotrione. An untreated control was included for comparison. Applications were conducted when waterhemp averaged 8 cm in height using a CO_2-pressurized backpack sprayer equipped with TT110015 flat-fan nozzle tips, calibrated to deliver 140.3 L ha^{-1} at 241.3 kPa. Visual estimates of weed control (%) were recorded on a scale of 0% (no control) to 100% (complete control) relative to the untreated check at 14 and 39 days after treatment (DAT). Data on weed control were subjected to analysis of variance (ANOVA), and treatment means were separated using Fisher's least significant difference (LSD) test at the 0.05 level of significance. All statistical analyses were conducted in R Studio (version 4.5.2). At 14 days after application (DAA), tank-mix treatments provided greater waterhemp control (95%-99%) compared to mesotrione and PS II herbicides applied alone. Mesotrione, atrazine and pyridate applied alone controlled waterhemp by 88%, 84% and 84%, respectively, while metribuzin and bromoxynil applied alone provided poor waterhemp control (48 and 40%, respectively). By 39 DAA, tank-mix treatments maintained higher waterhemp control (86-91%), similar to mesotrione applied alone (86%). Moreover, mesotrione applied alone presented greater control than atrazine (81%), pyridate (78%), metribuzin (48%), and bromoxynil (40%). These preliminary results suggest that tank-mixing mesotrione with PSII-inhibiting herbicides enhanced postemergence control of HPPD-resistant waterhemp compared with either herbicide applied alone, suggesting a synergistic interaction between the two sites of action. This synergism offers a valuable management tool for controlling resistant waterhemp populations and may help delay further resistance evolution in seed corn production systems. Future research will evaluate additional HPPD and PSII herbicides at multiple rates applied PRE and POST to confirm these synergistic interactions across diverse field environments, and this information could provide seed corn growers with effective and sustainable herbicide programs

Poster Section – Weed Biology & Ecology

83 - Common Purslane (*Portulaca oleracea*) and Redroot Pigweed (*Amaranthus retroflexus*) Management Strategies on Ohio Organic Soils

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[1]The Ohio state University

Common purslane (*Portulaca oleracea* L.) and redroot pigweed (*Amaranthus retroflexus* L.) are two of the most problematic weeds for vegetable growers in Ohio's organic muck soils. Producers typically use glyphosate for preplant weed control. However, inadequate common purslane control has been observed with glyphosate in organic soils, recreating need for alternative control options. Field experiments were conducted in 2025 in Willard, Ohio to evaluate the effectiveness of five preemergence (PRE) and six postemergence (POST) applied herbicides for managing common purslane (*Portulaca oleracea* L.) and redroot pigweed (*Amaranthus retroflexus* L.) on organic soil (40% organic matter) before crop planting. A randomized complete block design with four replications was used. Flumioxazin 106 g a.i. ha^{-1} + pyroxasulfone 134 g a.i. ha^{-1} PRE provided the highest level of common purslane (89%) and redroot pigweed (93%) control 3 weeks after treatment (WAT) and reduced common purslane and redroot pigweed aboveground biomass by 89%, and 95% compared to nontreated 4 WAT. Saflufenacil 50 g a.i. ha^{-1} and oxyfluorfen 561 g a.i. ha^{-1} PRE provided 84% and 75% common purslane and 74% and 66% redroot pigweed control, respectively 3 WAT. Bicyclopyrone 51 g a.i. ha^{-1} PRE provided the lowest common purslane (10%) and redroot pigweed (10%) control 3 WAT. Linuron 840 g a.i. ha^{-1} and saflufenacil 50 g a.i. ha^{-1} POST provided more than 94% control of common purslane and redroot pigweed control 3 WAT and reduced aboveground biomass by more than 94% 4 WAT. Flumioxazin 106 g a.i. ha^{-1} + pyroxasulfone 134 g a.i. ha^{-1} POST provided lowest common purslane control (55%) but provided 80% redroot pigweed control 3 WAT. Oxyfluorfen 561 g a.i. ha^{-1} POST provided the lowest redroot pigweed control (50%) 3 WAT. These results provide insights into 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.

84 - Emergence Patterns and Reproductive Potential of Goosegrass

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Goosegrass (*Eleusine indica* L.) is a warm-season annual that is considered globally among the most problematic weeds in agriculture. Historically, goosegrass has excelled in US rice and cotton production areas, but climate change has resulted in more frequent observations of populations in central Missouri. Research was initiated at 2 locations near Columbia, MO to determine the seasonal emergence pattern of goosegrass. A separate study considered biomass and fecundity of goosegrass established monthly throughout the growing season. For emergence studies, 400 viable seeds of goosegrass were uniformly distributed in each of six, 0.25 m2 square areas under no-till conditions. Prior to establishment, the experimental area was treated with a burndown herbicide to remove existing vegetation. Twice weekly seedlings were counted and removed with emergence monitored from May through September. Goosegrass emergence began in late May and continued through mid-July, peaking at both locations during the week of June 14th-20th with an average of 32 and 18 seedlings emerging per square at the different locations. Total emergence varied by location with 20% of the 400 seeds emerging at one location and only 8% emerging at the other. For the biology study, goosegrass seedlings were germinated under greenhouse conditions and up to 30, 2-3 leaf stage plants were transplanted into 2 field locations monthly from May through September, with seedlings spaced 15 cm apart. Seedlings were watered as needed through the establishment period. Plants were thinned after establishment until 6 plants were left. As plants transitioned to reproductive stages, seedheads were collected from each of the 6 plants throughout the growing season. As individual plants senesced, above ground biomass was harvested and the number of tillers was recorded. Although goosegrass is not considered a large annual weed, plants extensively tiller and generate prolific amounts of seed. Up to date harvest results show the May planted

goosegrass produced an average of 342 seedheads per plant with one plant reaching 745 seedheads, while June plantings slightly decreased to an average of 299 seedheads per plant.

85 - Emergence Patterns of Offspring from Early- and Late-Emerging Waterhemp (*Amaranthus tuberculatus*) Cohorts in Wisconsin

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Waterhemp [*Amaranthus tuberculatus* (Moq.) J.D. Sauer; Family Amaranthaceae] is currently ranked as the most difficult-to-control weed species in Wisconsin cropping systems and other regions of the U.S. Midwest. Understanding waterhemp emergence patterns across Wisconsin can aid in the development and implementation of timely and effective management strategies to minimize its impact on crop production. Our field scouting has revealed two major waterhemp emergence flushes in Wisconsin cropping systems: early cohorts emerging in mid-May to early June, and later cohorts emerging in late July. Therefore, common garden field studies under fallow conditions were conducted during the fall and spring of 2022-2023 and 2023-2024 at the Rock County Farm in Janesville, southern Wisconsin, to evaluate the emergence patterns of progeny from early- and late-season cohorts of five waterhemp accessions collected across Wisconsin (near Merrill, Clintonville, Lancaster, Brooklyn, and Altoona, WI). The experiment, arranged as a factorial combination of five accessions by two cohorts within accession (a total of ten accessions), was conducted in a randomized complete block design with four replicates. No differences in emergence patterns were observed among progeny derived from early- and late-season waterhemp cohorts. Waterhemp exhibited an extended emergence window, beginning in early May and continuing through late August, spanning approximately 18 weeks. The estimated growing degree day (GDD) accumulation required for 50% cumulative emergence varied slightly across accessions. However, except for the Brooklyn accession in 2023, waterhemp reached 50% cumulative emergence between 210 and 396 GDD, corresponding to early June in southern Wisconsin. Although waterhemp can emerge throughout the growing season, implementing early-season management strategies is critical to effectively target peak waterhemp emergence.

86 - Effect of Light Quality and Incubation Period on Seed Germination of Summer Annual Weeds

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Seed germination can be influenced by several factors, including light, temperature, and their diurnal variations. Growth chamber experiments were conducted in 2024 at the University of Minnesota to determine the effects of light quality (Red-to-far red ratio, R:FR = 1.2, 0.6, and 0), incubation period (0, 1, 2, 4, and 6 months), and incubation environment (variable and controlled) on the seed germination of Palmer amaranth (*Amaranthus palmeri* S. Wats.), waterhemp [*Amaranthus tuberculatus (*Moq.) Sauer], common lambsquarters (*Chenopodium album* L.), common ragweed (*Ambrosia artemisiifolia* L.), and giant ragweed (*Ambrosia trifida* L.). Seeds were incubated in two environments: soil-buried (variable temperatures and moisture) and refrigerator-stored (constant at 4°C). Freshly matured seeds showed higher dormancy, with germination rates <10% across all weed species and incubation environments. Germination increased over the incubation duration, particularly at the R:FR ratio of 1.2, with *A. palmeri, A. tuberculatus, C. album*, and *A. artemisiifolia* reaching maximum germination (72 to 81%) at six months after incubation. In contrast, seeds of *A. trifida* required longer incubation, and the highest germination rate (61%) was observed after 6 months of incubation at an R:FR ratio of 1.2 and in a variable environment. Seeds incubated in variable environments showed higher germination rates (58% to 79%) than those in controlled environments (51% to 69%) for all weed species. The percentage of non-viable seeds varied from 14% to 41% across species during six months of incubation. Light quality influenced radicle length, with the R:FR ratio of 0 resulting in the longest radicle. The results of this experiment showed that shading could negatively impact weed seed germination regardless of species, and that incubation conditions with diurnal variations helped overcome seed dormancy more rapidly than in a controlled environment. Additionally, extended incubation after seed maturity enhances dormancy loss, highlighting the role of temperature, moisture, and light cues in regulating germination ecology of summer annual weeds.

87 - Application Timing Effect of Saflufenacil and Pyroxasulfone in Tank Mix and Pre Mix

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Premix herbicides offer convenience in handling and storage compared to traditional tank-mixing approaches. Depending on the formulation, application timing, and rate, the use of premix herbicides can be less flexible. While some specific formulations may offer greater flexibility, questions remain regarding their performance when applied as premixes compared to traditional tank-mix combinations. The objective of this study was to evaluate the weed control of saflufenacil (76.7 g ai ha^{-1}) and pyroxasulfone (122.8 g ha^{-1}) when used separately, in tank mix, and in premix at two different timings. The study was designed as a randomized complete block with four replications in irrigated corn. Each treatment was used both as a pre-emergence and post-emergence treatment at the V3 stage, and an untreated check was included, resulting in a total of nine treatments. Applications were made with a backpack sprayer equipped with AIXR1102 nozzles spaced 51 cm apart, calibrated to deliver 140 L ha^{-1} carrier volume. Half of each plot was treated with a burndown tank mix including 466 g a.e. ha^{-1} of dicamba, 1,165 g a.i. ha^{-1} glyphosate, 20.4 g L^{-1} ammonium sulfate, and 2.03 L ha^{1} of a drift and volatility reducing agent. The reasoning for this burndown was to observe additional weed control and crop safety under field stress. Regardless of application timing, no crop response was observed for herbicides applied either pre- or post-emergence, whether delivered as separate applications, tank-mixes, or premixes. Weeds evaluated were *Setaria verticillata* (L.) P. Beauv. and *Amaranthus palmeri* S. Watson. Results indicate that there was no difference in control for S. verticillata and A. palmeri when applied pre-emerge, with the burndown areas of all plots showing superior control as expected. For A. palmeri applications made at the V3 corn growth stage, the front portions of all plots receiving burndown treatment showed no differences among treatments. In contrast, differences were observed on the back half of the plots without burndown, where treatments containing saflufenacil provided higher control than those containing pyroxasulfone.

These results suggest that some weeds were emerging at the time of application, highlighting the importance of aligning herbicide timing with weed emergence rather than crop growth stage alone. Future research may include evaluating different postemergence actives to target emerging weeds while maintaining the residual activity of the premix. Saflufenacil, alone or in a tank mix, can be used preplant or preemergence in corn for broadleaf weed control. In this study, it was included only for research comparison of premix and tank-mix treatments and should not be used in this way in field operations, as the product label does not support it.

88 - Quantifying Response of Plant Communities to Landscape Scale Farm Management Practices

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Human activity, including farming and sustainable practices, constantly influences plant ecology and the conditions under which different species grow. 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. This project represents the initial planning needed to implement long-term monitoring of plant biodiversity, emphasizing weed community composition, abundance, and spatial distribution, at Ohio State's 2000 acre Grace Drake Agricultural Laboratory (GDAL) in Wooster, Ohio. The assessment compares plant communities under two landscape-scale farm management practices, standard agricultural land management and agroecological land management, as well as the context provided by adjacent non-agricultural land (forest borders). The levels of plant biodiversity are expected to fluctuate due to the reaction of plant species to the disruption caused by human activity. This long-term project aligns with GDAL's mission to document agronomic and environmental outcomes under realistic working farm conditions. The study is conducted in two distinct cropland fields, the Standard Management Zone (featuring simple rotations, chemical fertilizers, and vertical tillage) and the Agroecological Management Zone (employing complex crop rotations, reliance on manure for fertility, and minimal/no tillage with diverse cover crops). To quantify the response of plant communities across these land management practices, we are developing a standardized sampling approach along line transects measured from the forest border towards the field center in both management zones. At predetermined, regular intervals along each transect, a standardized sampling frame is used to capture data. This process integrates with the advanced mapping system PlantMap3D. PlantMap3D uses computer vision and machine learning, integrating low-cost stereo cameras with cloud-based processing pipelines, to automate species identification, density estimation, and biomass mapping. Detailed data collected within the frame includes identification of all individual weed species, quantitative measurement of species cover and abundance (e.g., percent ground cover or plant counts), and potential biomass measurement. The resulting data allows for spatial analysis to generate detailed maps of weed distribution, height, and volume. Long-term outcomes of this monitoring effort will provide critical insights into weed population and community dynamics, supporting the selection of optimal land management practices for Ohio farmlands. By quantifying these long-term responses, this research facilitates the development of more precise and resilient integrated weed management strategies that combine preventive, cultural, mechanical, and chemical controls. The resulting data will be integrated

into an interactive online Geographic Information System (GIS) to visualize and analyze weed dynamics in relation to the distinct management zones over time.

89 - Asian copperleaf response to common postemergence herbicides

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Asian copperleaf is a new species finding its way into Iowa corn and soybean fields. This novel invader is native to eastern Asia and has not been previously found in crop field in the United States. As of 2025, infested fields have been found in 10 Iowa counties in the northern part of the state. Current efforts to understand the biology of this new copperleaf are underway, and initial studies have been conducted to determine it’s response to commonly used herbicides in corn and soybean. Seed from Asian copperleaf were collected from a field in central Iowa in the fall of 2024, cleaned and stored until trial initiation. Greenhouse studies were initiated in 2025. Plants were grown to a height of 7.5 cm and treated with POST herbicides. The herbicides applications consisted imazethapyr at 4 fl oz/A, lactofen at 12 fl oz/A, atrazine at 1 qt/A, mesotrione at 3 fl oz/A, glyphosate at 22 fl oz/A, glufosinate at 29 fl oz/A, 2,4-D at 24 fl oz/A, and dicamba at 22 fl oz/A. These rates represent the labeled rate for each herbicide. Appropriate adjuvants were included for each herbicide. 2,4-D and dicamba were evaluated for 28 days, all other herbicides were evaluated for 21 days after application. of Asian copperleaf treated with imazethapyr, atrazine, mesotrione, and dicamba resulted in control of 18.5, 39.5, 46.5, and 30.5% control, respectively. These herbicides represent three of the most commonly applied herbicides in corn in Iowa, and may provide insight why this weed is proliferating. Control improved with treatments of glyphosate and 2,4-D at 85 an 87.5%, respectively. Liberty treatments resulted in 91.5% control at 21 days after treatment, indicating it is effective. The greatest control was observed with lactofen, which provided 100% control of Asian copperleaf. While these results are initial studies and further research is needed, it is clear that there are limited options for control of Asian copperleaf in corn, and only a few options in soybean. Additional research on application timing and comparison of population response to herbicides in planned for future projects.

90 - Short Stature Corn Maternal Effects on Growth and Competitive Ability of Common lambsquarters (*Chenopodium album*)

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Maternal environmental effects impact weed competition and fitness. How abiotic and biotic stressors impact weed competition in short stature corn has not yet been evaluated. Therefore, greenhouse experiments were conducted to investigate the impacts of short stature corn plant population, water availability, and maternal effects on common lambsquarters (*Chenopodium album* L., CHEAL) competitiveness. This study followed a randomized complete block design with four replications repeated twice. Factorial treatment combinations consisted of 50 and 100% volumetric water content (VWC), two CHEAL populations collected from a field trial in East Lansing, MI under two short corn populations

79,000 (standard) or 99,000 (high) seeds ha^{-1}, and four CHEAL densities 0, 2, 4, or 6 plants pot^{-1} with one short stature corn planted into the center of each pot. Weekly measurements included plant height, leaf number, and corn stage. Aboveground biomass was collected after 6 weeks. All data except biomass were analyzed using the drc package in R. Biomass was analyzed using linear mixed effects models in R with means separated using Tukey’s HSD. Holding CHEAL density constant at 4 plants pot^{-1} and 50% VWC the high population reached 50% leaf production 3.8 days less than the standard population ($p<0.001$). Holding VWC and population constant at 100% and standard, increasing density from 4 to 6 plants pot^{-1} increased the time to 50% leaf production by 5.1 days ($p<0.001$). Holding density constant at 4 CHEAL pot^{-1}, with the standard population, time to reach 50% CHEAL height was 2.5 days faster for 100% VWC compared to 50% VWC ($p<0.001$). When CHEAL was in competition with 6 plants pot^{-1} and under the standard population decreasing VWC by 50% increased time to 50% height by 1.5 days ($p=0.01$). Time to 20, 35, or 50% maximum corn stage was not influenced by increasing density, VWC, or population ($p>0.05$). When corn was in competition with 4 CHEAL pot^{-1} and standard population decreasing VWC by 50% increased the time to 50% corn height by 4 days ($p<0.001$). Interestingly, when holding CHEAL constant at 6, corn under 100% VWC with standard population reached 50% maximum height 3 days less than corn under 50% VWC and high population ($p<0.001$). CHEAL biomass was modified by the main effect of density ($p<0.001$). Increasing CHEAL density from 2 to 4 or 6 plants pot^{-1} reduced biomass by 38 and 55%, averaged across population and VWC. Corn biomass was modified by the main effects of density and VWC ($p<0.001$, $p<0.001$). When corn was grown in competition with 2, 4, or 6 CHEAL plants pot^{-1} biomass was reduced by 22, 26, and 31% compared to no CHEAL competition, averaged across VWC and population. Reducing VWC by 50% reduced corn biomass by 41%, averaged across population and density. In conclusion, increasing short corn planting population impacts CHEAL offspring competitive ability. The cultural practice of increasing short statured corn seeding rate has long term impacts on CHEAL population dynamics.

91 - Response of Global Parthenium hysterophorus Populations to POST Herbicides

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Parthenium hysterophorus is an annual weed of global significance. Within its native range, spanning from the southern regions of North America to the northern parts of South America, the continuous use of herbicides such as glyphosate and paraquat has led to the selection of resistant *P. hysterophorus* populations. However, little is known about the global occurrence of resistance in *P. hysterophorus* or the available chemical control options. This study, conducted over two experimental runs, evaluated the efficacy of selected POST herbicides (0, 0.5X, and 1X label rates) commonly used in cultivated areas for managing *P. hysterophorus* populations. The study examined plants at two growth stages (4-6 leaf rosette and bolting) collected from locations in South Texas (Corpus Christi and College Station), Mexico, Australia, Israel, Pakistan, South Africa, and Vietnam. This study provides the first report of multiple-resistant *P. hysterophorus* populations from Australia, Israel, Pakistan, South Africa, and Vietnam. Populations from Corpus Christi and College Station, Texas, exhibited over 83% survival under glyphosate treatment at both rates at 21 DAA. Low-level glyphosate resistance (25% survival) was observed in populations from Israel and Vietnam when treated at the 4-6 leaf rosette stage. Most *P.*

hysterophorus populations exhibited some degree of tolerance to 1X rates of paraquat, mesotrione, glyphosate, and saflufenacil at the 4-6 leaf rosette stage. Tolerance of 1X rates at bolting increased for paraquat, atrazine, 2,4-D, and trifloxysulfuron with an average injury of 30%, 65%, 75%, and 75%, respectively. Survival of all *P. hysterophorus* populations, from agronomic and natural areas, to 1X rates of paraquat at the 4-6 leaf rosette and bolting stages with an average of 40% and 30% injury, respectively, suggests a level of natural tolerance to paraquat.

92 - Determining Emergence Windows 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 windows 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 windows 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 two research farms in corn and soybean rotation systems and fallow areas. 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 four-month period. 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.

93 - Environmental Factors Influencing the Differential Response of Resistant and Susceptible Waterhemp (*Amaranthus tuberculatus*) Populations to Glufosinate-ammonium

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The effectiveness of herbicides can vary significantly with environmental conditions, particularly temperature and relative humidity (RH). Although herbicides are generally more active under warmer temperatures and elevated RH, this relationship is highly species-specific and can differ across plant types (e.g., grasses vs. broadleaves) and even among biotypes with varying leaf wax composition or differing herbicide sensitivity. Glufosinate-ammonium (GA) has received particular attention in recent years due to its sensitivity to environmental factors and variability in application performance. In this study, we

evaluated the differential responses of a resistant waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] population (CAR; Carroll County, Illinois) and a susceptible population (WUS; Brown County, Ohio) to GA under varying environmental conditions post application. Plants were grown in a common greenhouse room and, after GA application, transferred to five different environments, each representing distinct temperature and RH regimes. Growth chambers were programmed to maintain day/night temperatures of either 31/26°C or 21/16°C, paired with RH levels of either 70/90% or 40/60%. The greenhouse served as a fifth environment with ambient conditions. Plants received eight GA rates (Liberty® Ultra, BASF Corporation, Florham Park, NJ), ranging from 0 to 5,256 g ha^{-1}, supplemented with ammonium sulfate at 2.5% of the application volume. Treatments were applied either midday (12:30-1:30 PM) or during the evening (7:30-8:30 PM). A completely randomized design was used within each environment, with four replications in the first experimental run and six in the second run. Aboveground biomass was recorded 21 days after treatment. Preliminary analyses indicate that the effects of temperature, humidity, and time of application were less pronounced than previously indicated in the literature. Differential responses between the resistant and sensitive population were observed across all environments and application times. More research is needed to determine at what time (i.e., pre or post application) environment has a more pronounced effect on GA efficacy.

94 - Impacts of Duration of Weed Competition on Weed Community Composition in Short vs. Traditional Stature Corn

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Corn (*Zea mays* L.) is the world's most economically important grain crop, but weed competition can reduce yield by 50%. Short-statured corn hybrids offer potential advantages such as decreased lodging susceptibility and compatibility for higher planting densities. However, their effects on weed ecology and competition dynamics remain unclear. The objective of this study was to evaluate how the duration of weed competition influences weed community composition and grain yield of short-statured corn hybrids compared with a traditional tall hybrid. This study was conducted in East Lansing, MI 2025 using a randomized complete block design with four replications. Factorial treatment combinations consisted of: three corn hybrids (tall, short-upright leaves, and short-pendulum leaves), two planting populations (79,000-standard and 99,000-high seeds ha^{-1}), and five weed-free durations (0, 2, 4, 6, and 8 weeks after planting). Weed-free periods were maintained with glyphosate. Each plot contained two 0.25 m^2 permanent subplots (A and B). Weed counts in A subplots began one week after each weed-free period ended and continued biweekly until 63 days after planting (DAP). To assess new weed emergence, weed counts began two weeks after the weed-free period ended in B subplots and continued biweekly until 77 DAP, at each sampling date emerged weeds were terminated with glufosinate. Aboveground weed biomass was collected at senescence before corn harvest. Weed community composition was evaluated using two metrics: Simpson's Diversity Index and Species evenness. All data were analyzed using linear mixed-effects models in R and treatment means were separated using Tukey's HSD. Grain yield was significantly affected by weed free duration and the two-way interaction between planting population and hybrid ($p<0.0001$, $p<0.0001$). Corn yield was the greatest when the tall hybrid was planted at the standard seeding rate, 13.37 t ha^{-1}. There was no difference in short-pendulum yield when planted at either population, however yield was reduced by 24% compared to the tall-standard. There was no difference in short-upright yield when planted at either population, however yield was reduced by 39% compared to the tall-standard. At harvest weed density was greatest in the 0 and 2 week periods ($p<0.0001$). Weed diversity was significantly altered by the weed-free duration ($p=0.01$) at 63 DAP. Diversity was 23% higher in 0 and 2 week weed-free durations compared to 4, 6, and 8 week weed-free durations. Species evenness at 63 DAP was significantly affected by the three-way interaction amongst hybrid, population, and weed-free duration ($p = 0.03$). The 8-week weed-free period resulted in an approximate 90% reduction in evenness across all hybrids and populations, driven by strong species dominance of annual grasses. The highest evenness generally occurred when weeds were suppressed for 4 to 6 weeks, regardless of population, suggesting that moderate early-season control promotes a more balanced weed community. However, the short-upright hybrid supported lower evenness than the tall and short-pendulum hybrids within this optimal window. Overall, there were no strong differences in the effects of weed density, diversity, or competition duration between short-statured corn and traditional-statured corn.

95 - Phytohormonal and Transcriptomic Mechanisms of Multigenerational Stress Memory in Wheat Under Weed Competition

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Crops frequently encounter diverse stressors, and plants have evolved a range of phenotypic, physiological, genetic, and biochemical mechanisms to cope. One such response, known as plant memory, allows plants to “store and recall” past stress experiences, potentially enhancing performance across generations. While this response has been examined in plant-pathogen interactions, its role in crop-weed competition remains underexplored. This study investigated multigenerational stress memory in wheat (*Triticum aestivum* L.) subjected to repeated competition with kochia [*Bassia scoparia* (L.) A.J. Scott], Italian ryegrass (*Lolium multiflorum* Lam.), and other wheat plants, examining phytohormonal regulation and transcriptomic reprogramming underlying these responses. Phytohormone analysis revealed increased salicylic acid levels, promoting systemic acquired resistance, while jasmonic acid declined, indicating suppressed jasmonate-mediated defense. Abscisic acid responses varied, reflecting shifts in water-use efficiency. Cytokinins and auxins showed generation- and treatment-specific trends, suggesting adaptive resource acquisition but potential hormonal imbalances. Transcriptomic analysis identified dynamic changes in differentially expressed genes (DEGs) and key pathways. Wheat-only competition peaked in stress-responsive DEGs in generation 3, while wheat-kochia and wheat-ryegrass exhibited early generation transcriptional reprogramming and long-term adaptations. Intra-specific wheat competition showed early generation transcriptomic surges but persistent growth repression. These findings provide insights into stress memory mechanisms, supporting strategies for enhancing wheat resilience and competition with weeds.

Poster Section – Weed Genetics & Herbicide Physiology

96 - Metabolism of mesotrione confers resistance in CYP transgene expressed wheat.

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Hydroxyphenylpyruvate dioxygenase (HPPD) inhibitors are among the most effective herbicides for broad-spectrum weed control in corn but not registered in wheat due to crop sensitivity. Corn can detoxify these herbicides via cytochrome P450 (CYP) enzyme activity. To explore a similar mechanism in wheat, we developed transgenic spring wheat lines that overexpress the *CYP81Q32-like* gene. These lines also exhibited high tolerance to mesotrione, suggesting that enhanced expression of this gene may facilitate degradation of mesotrione similar to corn. The objective of the study was to evaluate the metabolic fate of mesotrione by analyzing the absorption, translocation, and metabolism in T_4 generation transgenic wheat plants compared to wild-type (WT) plants using radiolabeled mesotrione. Individual plants were grown under controlled environmental conditions, and the fourth youngest leaf of wheat at 4 to 5 leaf stage was treated with a known amount of [phenyl-U-^{14}C]-mesotrione. Plant parts above, below along with the treated leaf were harvested at 6 and 24 hours after treatment and processed for analyses. The results showed no difference in ^{14}C mesotrione absorption or translocation between the WT or transgenic wheat, indicating that the transgene did not affect uptake and movement of mesotrione. However, the metabolic profiling using high-performance liquid chromatography revealed a distinct pattern in transgenic lines. At 6 and 24 hours after treatment WT plants retained ~99% of parent mesotrione compound, whereas the transgenic lines retained only ~8%. Additionally, a unique metabolite peak was found exclusively in the T_4 transgenic lines, confirming enhanced degradation of mesotrione. These results demonstrate that overexpression of the *CYP81Q32-like* gene in wheat leads to rapid mesotrione metabolism, supporting CYP-mediated detoxification as a key mechanism of herbicide tolerance. This approach offers a promising strategy for developing wheat varieties tolerant to HPPD-inhibiting herbicides.

97 - Investigating the Mechanism of Dicamba Resistance in a Population of Amaranthus tuberculatus from Illinois Through Integrated Metabolome and Transcriptome Profiling

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The increasing prevalence of non-target-site (NTS) herbicide resistance in weeds poses a growing challenge for weed management due to the frequent association with unpredictable cross-resistance. In a likely case of cross-resistance, a previously described multiple-herbicide-resistant population of waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] from Illinois (CHR) was recently identified as dicamba-resistant despite no recent recorded history of dicamba exposure. Genetic and transcriptomic evidence indicated a multigenic, NTS-based mechanism likely involving enhanced oxidative stress-response and herbicide translocation, but the specific biochemical basis remains unknown. Therefore, our objective was to compare the metabolic profiles of resistant and susceptible plants in response to dicamba treatment to (1) determine whether dicamba is derivatized, (2) identify differentially accumulated metabolites, and (3) identify metabolite-gene associations underlying resistance. To accomplish this, metabolic profiles of resistant and susceptible individuals from an F_2 line segregating for dicamba resistance were analyzed before and after (4 and 24 hr) dicamba treatment using targeted and untargeted liquid chromatography-quadrupole time-of-flight mass spectrometry. Targeted analysis did not reveal significant derivatization of dicamba, but resistant plants translocated dicamba from the contacted leaf tissue to the meristem at a significantly higher rate compared to susceptible plants. Consistent with observations of constitutive differences in the expression of resistance-associated genes, untargeted metabolomic analysis indicated clear differences in the metabolic profiles of resistant and susceptible plants both before and after treatment. Metabolite annotation and enrichment analyses are currently underway. Further integration with transcriptome data from these samples is expected to help narrow the gap from simple gene association to causation.

98 - Screening for multiple herbicide resistance in Amaranthus populations from Brazil

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The occurrence of pigweed (*Amaranthus hybridus* L.) biotypes resistant to glyphosate, characterized by a triple amino acid substitution (TAP-IVS) in the 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme, has increased in Brazil in recent years. Several of these biotypes also exhibit resistance to acetolactate synthase (ALS)-inhibiting herbicides. Consequently, the use of alternative herbicide modes of action, such as protoporphyrinogen oxidase (PPO) inhibitors, 4-hydroxyphenylpyruvate dioxygenase (HPPD) inhibitors, and auxin mimics herbicides, has become necessary. However, the intensified use of these herbicides may increase selection pressure, thereby favoring the evolution of biotypes with resistance to these alternative mechanisms of action. Therefore, the objective of this study was to evaluate the distribution of *Amaranthus* populations resistant to herbicides in Brazil and to confirm and characterize cases of resistance to PPO- and HPPD-inhibiting herbicides, as well as to auxin mimics herbicides. Seeds from 100 *Amaranthus* spp. populations collected from different fields and states across Brazil were obtained between 2023 and 2024. For the screening, 14 herbicide treatments were applied at 60% and 100% of the label-recommended rates, plus a non-treated control. The herbicides and application rates used were: glyphosate (558 and 930 g ha^{-1}), imazethapyr (64 and 106 g ha^{-1}), chlorimuron-ethyl (12.5 and 20 g ha^{-1}), 2,4-D (603 and 1005 g ha^{-1}), dicamba (432 and 720 g ha^{-1}), and mesotrione (115 and 192 g ha^{-1}), Tembotrione (46.2 and 75.6 g ha^{-1}), fomesafen (150 and 250 g ha^{-1}), oxadiazon (600 and 1000 g ha^{-1}), flumioxazin (35 and 60 g ha^{-1}) and tiafenacyl (71.2 and 118.65 g ha^{-1}). Populations that survived the label-recommended rates of HPPD- and PPO-inhibiting herbicides and auxin mimics were selected and advanced to the next generation (G1). From the G1 generation, dose-response experiments were conducted to confirm resistance, and DNA was extracted for characterization of Target-Site Resistance (TSR). For glyphosate, 83% of the populations were not controlled at the rate of 930 g ha^{-1}, indicating a widespread occurrence of resistance in the sampled areas. For chlorimuron-ethyl and imazethapyr, 40% and 47% of the populations, respectively, exhibited resistance to these herbicides. All populations evaluated were completely controlled by the auxin mimics and HPPD-inhibiting herbicides. For the PPO-inhibiting herbicides, 8,9% populations survived the label rate of fomesafen. Dose-response curves with the herbicides fomesafen and lactofen confirmed resistance to both herbicides. For fomesafen, populations 26-R and 48-R showed resistance factors (RF) of 65.6 and 434, respectively, and for lactofen, RF values of 80 and 3, respectively. This is the first report of resistance to PPO-inhibiting herbicides in *Amaranthus hybridus* in Brazil. The next steps of this study will involve characterizing the resistance mechanisms in the resistant populations, as well as determining the distribution of herbicide resistance cases among the 100 *Amaranthus* populations collected across Brazil.

99 - Effect of Temperature on Degradation of Soil Residual Herbicides

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Planting soybean early can result in more challenging weed management due to an extended period of competition between the crop and weeds, as well as the need to apply soil-residual herbicides under unfavorable conditions for herbicide metabolism. Wider implementation of early-planted soybean in the Central Corn Belt warrants research to investigate the persistence of commonly used soil-residual herbicides under cold soil conditions and their effects on weed control efficacy and crop injury potential. Preemergence (PRE) applications in early-planted soybeans are typically made under colder soil temperatures compared to PRE applications in later-planted soybeans. A greenhouse bioassay using velvetleaf (*Abutilon theophrasti* Medik) as a bioindicator species was conducted to evaluate the persistence of flumioxazin and pyroxasulfone in the soil and to examine the interaction between constant incubation temperature and soil properties on herbicide degradation. Data collection included velvetleaf height, density, and biomass. The greenhouse bioassay was arranged as a two-factor design for each soil residual herbicide, with Factor A including three soil incubation temperatures (27, 15, and 5 °C) and Factor B consisting of three soil types [sandy loam (1.5% O.M.), silt loam (2.5% O.M.), and silt loam (1.6% O.M.)] collected from different field sites in Indiana. A significant interaction was detected for soil type and incubation temperature for velvetleaf height, density, and biomass in soils treated with either flumioxazin or pyroxasulfone. At 14 days after planting (DAP), in flumioxazin-treated soil, sandy loam soil incubated at 5 °C resulted in a 75% reduction in velvetleaf density compared to soil incubated at 27 °C, while silt loam soil (1.6% O.M.) incubated at 5 °C resulted in an 85% reduction compared to 27 °C. At 14 DAP in silt loam soil (1.6% O.M.) treated with pyroxasulfone, incubation at 5 °C resulted in an 80% reduction in velvetleaf density compared to soil at 27 °C. Overall, in herbicide-treated soils, colder incubation temperatures resulted in increased herbicide persistence. The increased persistence of flumioxazin and pyroxasulfone may result from reduced microbial activity under colder soil conditions. Future research should investigate the effects of fluctuating temperatures on soil microbial activity and the persistence of flumioxazin and pyroxasulfone in field trials to determine whether applying these herbicides under colder conditions can enhance residual weed control.

100 - Do Biostimulants Mitigate Herbicide Stress In Sorghum?

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[1]Kansas State University, [2]Rosen's Inc

Crop injury from post-emergence herbicides poses a significant challenge in grain sorghum (*Sorghum bicolor ssp. bicolor (L.) Moench)* production, particularly when controlling competitive weeds like Palmer amaranth (*Amaranthus palmeri S. Wats*). Herbicides such as 2,4-D and dicamba are among the most effective labeled herbicides for broadleaf weed control but can induce phytotoxicity, negatively affecting grain sorghum yield. Plant bio-stimulants can support a plant’s natural processes to improve tolerance to abiotic stress.Their effectiveness to mitigate herbicide injury in grain sorghum remains understudied. A 2025 summer trial was conducted at Ashland Bottoms Research Farm near Manhattan, Kansas to evaluate the influence of biostimulants on grain sorghum injury and Palmer amaranth control by 2,4-D and dicamba. Pioneer 85P75 grain sorghum was planted in 76-cm rows at 60,000 seeds ha^{-1} with plot sizes of 3 × 9.1 m on June 11, 2025. Post-emergence treatments were applied on July 3 using TTJ (11002) nozzles calibrated to deliver 140 L ha^{-1} when weeds were 10 cm tall. Nine treatments consisting of 2,4-D or dicamba with and without one of three biostimulants (Mitigate Plus, Experimental A and Experimental B) were included. Visual ratings of crop injury and weed control were recorded 1, 2, 4, and 8 weeks after treatment (WAT). Data were subjected to analysis of variance, and means were separated using Tukey’s HSD. Herbicide had the greatest influence on sorghum injury, with 2,4-D causing 35 to 42.5% crop injury 2 WAT, while dicamba treatments showed 17.5 to 23.8% injury ($p<0.001$). Mitigate reduced crop injury 2 WAT from 42.5 to 35.0% when combined with 2,4-D. Experimental A and Experimental B showed minimal protective effect for both herbicides. By 8 WAT, injury ranged from 11.7 to 30% with no significant differences ($p= 0.563$). Palmer amaranth control was greater for dicamba-based treatments (75.0 to 85.0%) compared to 2,4-D treatments (60.0 to 70.0%) at 2WAT. These findings demonstrate that some biostimulants may reduce crop injury by 2,4-D in grain sorghum.

101 - Influence of Application Time of Day and Weed Size on Glufosinate Efficacy in a Problematic Waterhemp Population

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[1]Purdue University, West Lafayette, IN

Glufosinate use has increased rapidly over the past decade and plays a key role in managing many herbicide resistance weeds, especially in soybeans 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 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 problematic waterhemp (*Amaranthus tuberculatus*) population at varying weed sizes and application time of day. This experiment was a randomized complete block design with five replications completed twice in time. Herbicide treatments consisted of no herbicide and glufosinate applied at 330 and 660 g ai ha^{-1} with 4.9% v/v AMS. In run 1, five plants per plot were flagged at 8-10 cm and the average whole plot height was 8-10 cm at application. In run 2, five plants were flagged per plot for each 8-10 cm and 15-20 cm plant heights, with an average whole plot height of 15-20 cm at application. Glufosinate was applied one hour after sunrise, solar noon, and one hour before sunset for both runs. For run 1, whole plot visual control of waterhemp at 330 g ha^{-1} differed between application times at 21 DAT, with sunset providing the greatest waterhemp control (89%). No differences were observed for application time of day when glufosinate was applied at the higher rate of 660 g ha^{-1}. Conversely, control of waterhemp in the second run was greatest with the sunrise application but only reached 52% and 76% control for glufosinate applied at 330 and 660 g ha^{-1}, respectively. Control or biomass reduction of marked waterhemp plants in each plot did not differ by weed size or application time of day. The marked plants were carefully selected for uniform size and isolated from adjacent plants prior to application by removing other waterhemp plants within a 15 cm radius from the marked plant. Furthermore, environmental conditions were ideal for glufosinate efficacy on both application dates with relative humidity and temperature greater than 75% and 21 C on average. In conclusion, the influence of application time of day on glufosinate efficacy for the whole plot data was greater in treatments that had a high plant density and 15-20 cm weed size, most likely due to plant canopy interference that reduced spray coverage. However, the influence of treatment factors may have been muted on marked plants by allowing for more optimal spray coverage from the plant isolation methods employed prior to the herbicide application. This research highlights that variable plant heights, application time of day, and spray coverage in dense plant populations may be contributing to variable efficacy of glufosinate in commercial applications.

102 - Response of Pigweed (*Amaranthus* spp.) Populations in Kansas to Glufosinate, Dicamba and 2,4-D

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Amaranthus species, including waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer) and Palmer amaranth (*Amaranthus palmeri* S. Watson), are among the most troublesome weeds in Kansas cropping systems. The repeated use of postemergence herbicides with similar sites of action has reduced herbicide sensitivity in these species. In October 2024, seed samples of *Amaranthus spp*. were collected from soybean (*Glycine max* L.) fields across Kansas to evaluate their response to three herbicides commonly used in soybean production: glufosinate, dicamba, and 2,4-D. Seedlings were established in plastic trays measuring 25 x 51 cm containing potting substrate and thinned to approximately 30 plants per tray. When seedlings were 10 to 12 cm tall, they were sprayed separately with glufosinate (0.98 kg a.i. ha^{-1}), dicamba (0.56 kg a.i ha^{-1}), and 2,4-D (1.06 kg a.i ha^{-1}) using a single-nozzle track sprayer. A non-treated control was included for each population. Herbicide injury was visually rated weekly for 4 weeks after treatment (WAT). Plant mortality was recorded 28 DAT. Among the 28 populations evaluated, glufosinate provided variable control: 48% of populations were controlled (0-10% survival), while 24% had poor control (31-60% survival) and glufosinate applications failed to control 8% of the populations (more than 60% survival). Four populations were identified as needing further investigation to confirm resistance. For 2,4-D, 46% of the populations were fully controlled, while 17% showed poor control. Only one population warrants further investigation for 2,4-D resistance. Dicamba achieved the greatest efficacy, with 67% of populations showing complete control and none categorized as poor control. Overall, these results reveal differences in response to these three herbicides among the *Amaranthus* populations evaluated. Reduced sensitivity to glufosinate and 2,4-D may be emerging in some areas of Kansas. Continued monitoring and adoption of integrated weed management strategies are essential to preserve herbicide effectiveness.

103 - Turning Stress into Strength: Glyphosate Hormesis Enhances Growth and Water-Use Efficiency in Ivyleaf Morningglory

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[1]University of Nebraska - Lincoln

Sublethal exposure to herbicides frequently occurs under field conditions due to drift or uneven spray coverage. Such exposures can trigger hormetic responses, in which plants exhibit enhanced growth and improved fitness compared to untreated individuals. A greenhouse study was conducted in 2025 at the University of Nebraska-Lincoln to evaluate the growth and physiological responses of ivyleaf morningglory (*Ipomoea hederacea* Jacq.) to increasing doses of glyphosate. Plants at the BBCH 12-13 growth stage (two to three true leaves) were sprayed with 0, 225, 449, 899, 1,348, 1,797, or 2,888 g ae ha^{-1} of glyphosate. Biomass, chlorophyll content, and gas-exchange parameters were measured weekly for 4 weeks after treatment (WAT). Chlorophyll content was determined using a SPAD-502 Plus meter, while photosynthetic rate (A), transpiration rate (E) and instantaneous water-use efficiency (A/E) were measured with a LI-COR 6800 portable photosynthesis system. The instrument was set to operate at a reference CO_2 concentration of 400 µmol mol^{-1} and an airflow rate of 500 µmol s^{-1}. Sublethal glyphosate doses (225 and 449 g ae ha^{-1}) increased biomass by up to 85% and chlorophyll content by up to 40% compared with untreated plants. Despite the increase in biomass, these same doses did not result in higher photosynthetic rate. However, plants exposed to 225 and 449 g ae ha^{-1} exhibited improved instantaneous water-use efficiency (A/E), primarily due to a reduction in transpiration, while maintaining similar photosynthetic rates to the control. These results indicate that sublethal doses of glyphosate can improve physiological performance and stress tolerance in ivyleaf morningglory. Considering the potential for hormetic effects and the natural tolerance of morningglory to glyphosate, alternative herbicides should be considered for its effective control.

104 - Dose-Response Characterization of Multiple Wisconsin Herbicide-Resistant Amaranthus tuberculatus Accessions

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Multiple-herbicide-resistant waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer) is one of the major weed problems in the U.S. Midwest corn-soybean production systems. Previous waterhemp screening in Wisconsin identified several accessions with suspected resistance to herbicides applied at label rates from a range of modes of action. Therefore, the objective of this study was to characterize the response of eight concerning Wisconsin waterhemp accessions to multiple herbicides. Dose-response greenhouse experiments were conducted to evaluate the sensitivity of A92, A101, A106, A117, A121, A125, A133, and IL to postemergence (POST) applications of 2,4-D (1×: 1065 g ai ha^{-1}), atrazine (1×: 560 g ai ha^{-1}), fomesafen (1×: 263 g ai ha^{-1}), and mesotrione (1×: 105 g ai ha^{-1}), as well as preemergence (PRE) applications of atrazine, fomesafen, mesotrione, and S-metolachlor (1×: 1785 g ai ha^{-1}). For every accession, herbicide rates ranged from 0.062× to 8× the label-recommended rate. A non-treated control

(NTC) was included for each herbicide treatment. POST applications were made when plants reached 5 to 10 cm in height, and preemergence treatments were applied after planting. For the POST experiment, biomass was collected at 21 days after treatment (DAT) and expressed as percent biomass compared to NTC. For the PRE experiment, established plants were enumerated 28 DAT and converted to percent plant count relative to the NTC. Preliminary results indicate that at least three accessions exhibited high levels of resistance to 2,4-D and fomesafen POST. Experiments and results for the other POST and all PRE herbicide treatments are being finalized and will be presented during the conference. Lastly, results from these experiments will be contrasted with ongoing agar-based dose-response assays in an attempt to validate the use of the latter as a rapid and reliable methodology for herbicide resistance investigation.

105 - dndsR: A high-throughput pipeline for calculating and analyzing evolutionary selection pressures between species

Nick Johnson[1], Luan Cutti[1], Todd Gaines[2], Eric Patterson[1]

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Understanding the genomic basis of weediness is essential for developing effective weed control strategies and ensuring global food security. Recent initiatives by the *International Weed Genomics Consortium* (IWGC) have generated numerous previously unavailable genomes for weedy species. These resources enable large-scale comparative analyses between weeds and their non-weed relatives, offering insights into the genetic factors that make weeds adaptive and competitive in agricultural environments. To fully leverage these datasets efficiently, automated computational workflows are needed. One such approach involves analyzing evolutionary selection pressures using the ratio of non-synonymous to synonymous substitutions (dN/dS) between orthologous genes. This metric reveals which genes are conserved or diverging between species, which we hypothesize can help identify genes potentially underlying weediness. Here, we present **dndsR**, an R package for large-scale dN/dS computation and analysis across species, alongside **iwgc-circos**, a small companion workflow for rapidly generating Circos plots of key genomic features. We demonstrate their use through a case study comparing the IWGC *Chenopodium album* genome with a publicly available assembly of its crop relative, *C. formosanum*.

106 - Towards a Genome-Wide Association Study to Identify Genes Influencing S-metolachlor sensitivity in Waterhemp (*Amaranthus tuberculatus*)

Rishabh Singh[1], Travis Wilke[1], Aaron Hager[1], Tiffany Jamann[1], Patrick Tranel[1]

[1]University of Illinois at Urbana-Champaign

Waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] is one of the most troublesome weed species in U.S. cropping system with evolved resistance to herbicides across seven 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 program for managing grass and small-seeded broadleaf weeds, including waterhemp. Recently, two population from Illinois were reported resistant to *S*-metolachlor through enhanced metabolism via Phase I and Phase II metabolism reaction, mediated by

cytochrome P450 monooxygenases (CYPs) and glutathione *S*-transferases (GSTs). However, the specific genes coding for the CYPs and GSTs responsible for *S*-metolachlor metabolism in waterhemp remain unknown. Both CYP and GST belong to large gene families involved in diverse biotic and abiotic stress responses in plants, making the identification of specific genes challenging. The objective of this research is to identify genomic regions associated with *S*-metolachlor sensitivity in waterhemp via a genome-wide association study. Waterhemp accessions were collected in fall 2023 from 127 locations across Illinois. Inflorescences from two female plants were sampled from each location, supplemented with public submissions and previously characterized resistant and susceptible populations, yielding 257 total accessions. All accessions were screened with three rates of *S*-metolachlor: 0 kg ai ha^{-1} (control), 0.4 kg ai ha^{-1} (low rate) and 0.8 kg ai ha^{-1} (high rate). At 21 days after herbicide treatment, percent emergence and plant stunting were recorded. Additionally, leaf tissue samples were collected from the most stunted plants with *S*-metolachlor injury at low dose (classified as sensitive) and from the healthiest plants surviving the high dose (classified as resistant). Tissue samples will be subjected to low-coverage whole-genome sequencing, and resulting phenotypic and genotypic data will be analyzed to identify SNPs and genomic regions associated with *S*-metolachlor resistance in waterhemp. Results from this study will advance our understanding of the genetic basis of metabolic herbicide resistance and may facilitate the identification of specific CYPs and GSTs involved in *S*-metolachlor detoxification in waterhemp.

107 - Decoding the Evolutionary History of Sex Determining Regions in Amaranthus via Ancestral Reconstruction

Ramandeep Kaur[1], Patrick Tranel[1]

[1]University of Illinois Urbana-Champaign

The genomic evolution of sex-determining regions (SDRs) in the genus *Amaranthus* remains poorly understood despite the coexistence of monoecious and dioecious reproductive systems within the lineage. In *Amaranthus palmeri*, a male heterogametic system and a ~1.3 Mb male-specific region suggest the presence of a young Y chromosome, whereas in *Amaranthus tuberculatus*, a ~3 Mb region on Chromosome 1 exhibits high haplotype diversity and incomplete genotype-phenotype correspondence; features consistent with an independent origin of dioecy in the genus. Although both species are dioecious and closely related, their contrasting sex chromosome architectures raise a fundamental evolutionary question: whether their SDRs arise from a shared ancestral locus or from convergent evolution. Understanding their origin and gene-order evolution can illuminate the structural and functional mechanisms underlying sex chromosome diversification in *Amaranthus*. To address this, we employ an integrative phylogenomic-synteny framework combining orthology inference, ancestral gene-order reconstruction, and chromosome-level karyotype modeling. FastOMA software package is used to identify hierarchical orthologous groups (HOGs) across eleven *Amaranthus* genomes representing both reproductive systems, along with selected outgroups. EdgeHOG tool is then applied to infer ancestral gene adjacencies and reconstruct gene-order evolution along the *Amaranthus* phylogeny. To further validate and visualize chromosomal rearrangements, we use the AKRUP (Ancestral Karyotype Reconstruction Universal Pipeline), which models ancestral chromosomal architectures and identifies conserved synteny blocks linked to major evolutionary transitions. Together, these analyses provide an evolutionary framework for comparing SDR structure, ancestry, and rearrangement history in *A. palmeri* and *A. tuberculatus*, distinguishing ancestral from lineage-specific genes, and revealing the genomic mechanisms underlying repeated transitions to dioecy in *Amaranthus*.

108 - Confirmation of Glyphosate-Resistant Common Lambsquarters (Chenopodium album), in Minnesota

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[1]University of Minnesota, [2]North Dakota State University, [3]Michigan State University

Common lambsquarters (*Chenopodium album*) is one of the most troublesome broadleaf weeds threatening agronomic crop production in Minnesota. Continuous reliance on herbicides in agricultural systems has contributed to the evolution of herbicide-resistant biotypes. A greenhouse experiment was conducted to confirm and quantify glyphosate resistance in common lambsquarters biotypes from Minnesota and North Dakota. Putative glyphosate-resistant common lambsqurters biotypes were collected from soybean and sugar beet fields between 2022 and 2024. Treatments consisted of eight glyphosate doses (0.0625x, 0.125x, 0.25x, 0.5x, 1x, 2x, 4x, and 8x the recommended field rate), and a nontreated check. Each treatment was replicated five times and repeated in two experimental runs. Common lambsquarters plant injury was assessed visually at 7, 14, and 21 days after treatment (DAT), and aboveground biomass was harvested at 21 DAT. Dose-response data were analyzed using a four-parameter log-logistic function using the *drc* package in R. This poster will present results from a dose-response study comparing the effective doses required for 50% and 90% control (ED_{50} and ED_{90}) of putative resistant biotypes with those of a susceptible check to determine the level of resistance. Confirmation of glyphosate-resistant common lambsquarters would further complicate the management of this weed species in row crop production in the Upper Midwest.

General Session

109 - Welcome to the 80th North Central Weed Science Society Annual Meeting

Brett Miller*,

Syngenta Crop Protection, Ellston, IA

110 - Michigan Agriculture

Tim Boring*,

Director, Michigan Department of Agriculture & Rural Development, Lansing, MI

111 - A Classroom of American Democracy: Exploring the Gerald R. Ford Presidential Museum

Mirelle Luecke*,

Supervisory Curator, Gerald R. Ford Presidential Library & Museum, Grand Rapids, MI

112 - Presidential Address

Mark Bernards*

Rosen's Inc, Morris, MN

113 - Washington, D.C., Science Policy Update

Lee Van Wychen*;

Weed Science Society of America, Alexandria, VA

114 - NCWSS Finance Update

Eric Spandl*;

Winfield United, River Falls, WI

115 - Remembering NCWSS Members and Friends

Zach Rystrom*;

Midwest Research Inc, York, NE (115)

116 - Program Announcements

Brett Miller*,

Syngenta Crop Protection, Ellston, IA

Student Contest – Row Crop Herbicide / Cover Crops & Integrated Weed Management

117 - Effect of Metribuzin and Sulfentrazone Rate and Combination on Waterhemp (*Amaranthus tuberculatus*) Control and Crop Safety Across Soil Types

Austin Weippert[1], Joseph Ikley[1]

[1]NDSU Plant Science

Increasing weed resistance to soybean postemergence herbicides across North Dakota is leading to an increased interest in preemergence herbicides. However, there are concerns about weed control and crop injury from growers across different soil types throughout the state. The objectives of this research were to evaluate different rates and mixtures of metribuzin and sulfentrazone on weed control and crop safety on two different soybean [*Glycine max* (L.) Merr] varieties across three unique soil types. Field experiments were conducted during the 2024 and 2025 growing seasons in Fargo, ND (clay soil with 5.3% OM and pH of 8.0), Hillsboro, ND (loam soil with 5.2% OM and a pH of 6.8), and Glyndon, Minnesota (sandy loam soil with 2.2% OM and a pH of 8.3). Crop safety experiments were conducted at all sites, while weed control experiments were only conducted at Fargo and Glyndon. The experiments were a randomized complete block design (RCBD) arranged in a split-block of a metribuzin tolerant, sulfentrazone susceptible variety compared to a metribuzin susceptible, sulfentrazone tolerant variety. Herbicide treatments were arranged in a factorial structure consisting of metribuzin applied at 0, 280, or 560 g ai ha^{-1}, and sulfentrazone applied at 0, 140 or 280 g ai ha^{-1}. For crop safety trials, visible crop injury was evaluated at 3, 7, 14, and 28 days after emergence (DAE) on a 100% scale (0 = no injury and 100 = complete plant death), stand counts were recorded at 14 DAE and plant heights were measured at 28 DAE. The plots were kept weed free and yield was collected. For weed control trials, visible weed control was evaluated 14, 28, and 42 days after treatment (DAT) on a 100% scale (0 = no weed control and 100 = complete plant death). Waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] densities were recorded with two separate $0.5m^2$ quadrats 28 and 42 DAT with a biomass collection at 42 DAT. In 2024 and 2025 injury was present at all evaluation timings at Glyndon with 560 g ai ha^{-1} of metribuzin-treatments exhibiting the most injury. Injury persisted across the second and third evaluation timing at Fargo from metribuzin at 560 g ai ha^{-1} plus sulfentrazone at 140 g ai ha^{-1} in 2025 only. No visible injury was observed at Hillsboro either year. Both site years saw no yield differences compared to the herbicide-free check across all locations. Severe Iron Deficiency Chlorosis (IDC) was prevalent at Glyndon and led complete stand loss in 2025. There were no differences in herbicide treatments on weed control in 2024 in Glyndon. In 2025, all herbicide treatments led to higher waterhemp densities but lower biomass. At Fargo in both years, all treatments reduced waterhemp density and biomass compared to the check. Metribuzin at 560 g ai ha^{-1} plus sulfentrazone at 280 g ai ha^{-1} resulted in over 90% control across all evaluation timings in 2025. Further research will include greenhouse experiments to evaluate these treatments on the same soils under controlled amounts of precipitation.

118 - Novel Application of Root Analysis Software to Classify Soybean Line Sensitivity to Saflufenacil in Hydroponic Assay

Emma J. Lagerhausen[1], Emerson L. Espinosa[1], Julie M. Young[1], Katy M. Rainey[1], Bryan G. Young[1]

[1]Purdue University

Saflufenacil is a protoporphyrinogen oxidase (PPO)-inhibiting herbicide used to control broadleaf weeds in soybean (*Glycine max* (L.) Merr.) prior to emergence. In cool and wet conditions, that can occur during soybean emergence, PPO-inhibiting herbicides can cause injury to seedlings. Because this injury is environment and cultivar dependent, the goals of this study were to 1) screen 200 public lines using a hydroponic assay and classify them as "tolerant" or "sensitive" to saflufenacil relative to known tolerant and sensitive commercial benchmark cultivars, 2) determine the relevant root traits for cultivar classification, and 3) compare these results to those obtained from unmanned aerial systems (UAS) imagery from relevant field studies. Hydroponic assays were conducted in the growth chamber using ten replicates and two experimental factors: saflufenacil dose (0 or 80 ppb) and soybean line (n=197). Soybeans were germinated in vermiculite until radicles measured approximately 5 cm. Seedlings were then placed in hydroponic solution, acclimated in the growth chamber for 8 hours in complete darkness, then grew in cycles of 16 hours of light followed by 8 hours of darkness. Soybeans were harvested after five days of growth, when the unifoliate leaves of nontreated plants unfurled. Root and shoot tissue were separated and roots were scanned on a flatbed scanner, then oven dried to determine dry weight. Root images were processed using RhizoVision Explorer to calculate length, diameter, and volume. The percent reduction of each treated replicate was calculated relative to the nontreated control, and a principle component analysis (PCA) was conducted to determine the most relevant root traits. Data were analyzed with Welch's t-tests ($\alpha \leq 0.05$), with the mean of the tolerant and the sensitive benchmark cultivars compared to the mean of each soybean line of unknown sensitivity to saflufenacil for each trait, with correction for multiple comparisons. Of the lines evaluated in this study, 60% were classified as tolerant to saflufenacil, 30% were classified as sensitive, and 10% were unable to be classified as tolerant or sensitive. The field and hydroponic assay were in agreement on the classification of a soybean line as tolerant for 80% of the lines evaluated. These two approaches yielded less agreement (55%) for classifying a soybean line as sensitive. This research highlights the importance of root traits in classifying sensitivity to PPO-inhibiting herbicides, potential shortcomings in UAS-acquired measurements, and the utility of hydroponic assays.

119 - Herbicide Tank-Mix Concepts for Preemergence Waterhemp (*Amaranthus tuberculatus*) Control to Be Used in Future Soybean Technologies

Carson Hought[1], Joseph Ikley[1]

[1]North Dakota State University

Waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] is a problematic weed in many soybean [*Glycine max* (L.) Merr.] fields in the Northern Great Plains, where waterhemp has evolved resistance to at least 4 different herbicide sites of action. With few remaining effective postemergence options, there is renewed interest in utilizing preemergence herbicides to control waterhemp and other problematic weeds. Concurrently, soybean varieties are being developed that will be tolerant to glyphosate, glufosinate, dicamba, 2,4-D, and mesotrione. The objective of this experiment was to evaluate different preemergence herbicide combinations that will be available for weed control in these soybean systems. Two bare-ground field trials were conducted in 2024 and 2025 in Glyndon, Minnesota (sandy loam soil) and Fargo, North Dakota (clay soil) to evaluate preemergence tank-mixes on waterhemp control. Experiments were a randomized complete block design (RCBD) arranged in a 2 x 2 x 2 x 2 factorial. Factors consisted of herbicide active ingredient (ai) which were dicamba, mesotrione, metribuzin, and encapsulated-acetochlor. Each factor consists of two levels; 0x and 1x the labeled rate of herbicide ai ha^{-1} for the Fargo, ND region. Weed control was assessed at 28, 42, 56, and 70 days after treatment (DAT) using visible control ratings, with a scale of 0 to 100 percent (0 representing no control and 100 representing complete plant death). Waterhemp density was measured within 2, 0.5-m^2 quadrats at 42 and 70 DAT, and biomass collected at 70 DAT. Data were analyzed using ANOVA, and treatment separation analyzed with Fisher's protected LSD with α=0.05. In 2024 abnormally high precipitation and low temperature delayed waterhemp emergence at both locations. More than 15cm of precipitation was received within 21 d after trial initiation. Treatments containing encapsulated-acetochlor resulted in greater waterhemp control at both locations 42 DAT and 70 DAT in 2024. Biomass was reduced by 99% and 70% with treatments containing encapsulated-acetochlor in Glyndon and Fargo respectively in 2024. In 2024, Fargo treatments containing metribuzin and encapsulated-acetochlor reduced waterhemp biomass by 90%. Waterhemp density was the lowest at both locations when treatments containing encapsulated-acetochlor were applied in 2024. Treatments containing encapsulated-acetochlor reduced waterhemp density by 68% compared to treatments without encapsulated-acetochlor 70 DAT at Fargo in 2025. Biomass was reduced by 83% when mesotrione, metribuzin, encapsulated-acetochlor were tank-mixed compared to the non-treated at Fargo in 2025. No treatments reduced waterhemp biomass or density 70 DAT in Glyndon in 2025. Wind erosion at the site may have impacted the results. These results indicate that tank-mixing mesotrione with encapsulated-acetochlor and mesotrione with encapsulated-acetochlor and metribuzin can reduce waterhemp density and biomass in the Northern Great Plains. Tank-mixing effective multiple herbicide sites of action such as mesotrione, metribuzin, and encapsulated-acetochlor may lessen waterhemp selection pressure for herbicide resistance. Applying these herbicides together will allow farmers to be more flexible in their approach to waterhemp control for future soybean technologies.

120 - Investigating Delta-T Influence On Glufosinate Efficacy For Palmer Amaranth (*Amaranthus palmeri*) Control In Soybeans

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Effective management of Palmer amaranth (*Amaranthus palmeri S. Wats*) in soybean production often requires late-season herbicide applications, but environmental factors such as relative humidity influence efficacy. For instance, a Delta T below 2C signals high humidity and slower evaporation, potentially improving uptake but risking droplet runoff or increasing off-target movement. Conversely, a Delta T above 10C indicates low humidity and rapid evaporation, which can cause droplets to dry before penetrating plant cuticles. Adding 2,4-D choline to glufosinate may improve weed control, but multi-year evaluations under variable conditions are needed to guide application strategies, especially for large weeds in the Great Plains. This study was conducted at Manhattan, KS (2024 and 2025) and Hays, KS (2025), to assess the impact of Delta T on Palmer amaranth control with glufosinate alone or tank-mixed with 2,4-D choline, applied at 93.5 or 187 L ha^{-1}. Plots were 3 × 9.1 m, and treatments were replicated 4 times at each location. Post-emergence treatments were applied when weeds reached 20 cm using TTJ (11003) nozzles for glufosinate (Liberty 280 SL, 0.655 kg ai ha^{-1}) only treatments and AIXR (11003) nozzles when 2,4-D choline (Enlist One, 0.532 kg ai ha^{-1}) was included.Each herbicide by spray volume combination was applied 4 times with different Delta T values at each location. Delta T ranged from 3.6 to 12.8°C in 2024 and 2.5 to 7.9°C in 2025**.** All treatments at each location were completed within a 10-day period during daylight hours (at least 2 hours after sunrise and 3 hours before sunset) and Delta T was recorded during application period. Visual ratings of weed control were recorded 1 and 3 weeks after treatment (WAT). Data were subjected to analysis of variance, and means were separated using Tukey's HSD. Results indicated that the relationship between Delta T and Palmer amaranth control 3 WAT was influenced by year ($p < 0.001$), requiring separate analysis by year**.** Delta T influenced Palmer amaranth control 3 WAT at Manhattan in 2024.Control by glufosinate alone was 91.6% within optimal Delta T (2-10) and 55.9% for high Delta T (>10). When 2,4-D choline was included, weed control was 93.2% at optimal Delta T and 62.8% at high delta T. The Delta T range was less in 2025, and control was 80.6% for glufosinate alone and 87.3% for glufosinate + 2,4-D choline across all conditions. The observed differences between glufosinate alone and when combined with 2,4-D choline represent numerical increases but are not statistically significant for both years. Carrier volume showed a trend toward interacting with Delta T, with a greater effect on applications made at 93.5 L ha^{-1} (slope = -4.01) compared to 187 L ha^{-1} (slope = -3.38), though this difference was not statistically significant. These findings demonstrate that applying herbicides within optimal Delta T enhances control (92.5%) of larger Palmer amaranth compared to higher Delta T (59.4%).

121 - Exploring Weed Management Strategies for Short Stature Corn in Michigan

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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, the ability to withstand severe weather, and increased planting populations, which can have positive impacts on weed control. However, best weed management practices in short statured corn are unknown. 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 performance. This study was conducted at two locations in East Lansing and Morrice, MI in 2024 and 2025, and followed a randomized complete block design with four replications. Factorial treatment combinations consisted of three corn hybrids (tall, short-upright leaves, and short-pendulum 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). The following measurements were taken throughout the season: weed control, crop injury, leaf orientation, leaf angle, drone imagery (Morrice only), and canopy closure. Weed biomass, corn ear height, and yield were collected at the end of the season. All data except canopy closure were analyzed using linear mixed-effects models in R and means were separated using Tukey's HSD. Canopy cover data were analyzed using the drc package in R. Twenty-one days after post application (DAP), annual grass control in East Lansing 2024-2025 was modified by the main effect of herbicide ($p<0.001$). Annual grass control in the

Two-pass system was 5, 10, and 99% greater than the PRE, EPOS, and non-treated averaged across population and hybrid. When holding hybrid constant (pendulum) and population (standard) in East Lansing 25 the time for the Two-pass program to reach 50% canopy closure was 10.1 days less than the control ($p<0.001$). Additionally, holding hybrid constant (tall) and population (standard) the PRE treatment reached 50% canopy closure 2.5 days longer than the EPOS treatment ($p=0.02$). When holding hybrid constant (upright) and population (high) in Morrice 25 time for the EPOS program to reach 50% canopy closure was 5 days less than the control ($p<0.001$). Yield at East Lansing 24 was modified by the main effect of herbicide program and the two-way interaction between hybrid and population ($p<0.001$, $p<0.001$). Yield in the pendulum-standard was 10, 14, 18, and 21% lower than the upright-standard, pendulum-high, upright-high, and tall-standard, averaged across herbicide treatments. Yield in the PRE treatment was 22% higher than the untreated control, averaged across hybrid and population. Yield in East Lansing 2025 was modified by the main effect of herbicide ($p<0.001$). There was no difference between the Two-pass, EPOS, and PRE timings averaged across population and hybrid. However, there was over 300% difference when weeds were not controlled compared to all other treatments. Yield at Morrice 24 was modified by the three-way interaction between herbicide, population, and hybrid ($p=0.003$). Yield in the upright-high-Two-pass was 22, 24, and 25% greater than upright-standard PRE, upright-standard-EPOS, and upright-standard-Two-pass. In conclusion, short stature corn weed management, and canopy closure rate are similar to traditional corn.

122 - Effect of Pre-Emerge Herbicide on Iron Deficiency Chlorosis Severity in Soybean on High pH Soils

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Iron Deficiency Chlorosis (IDC) is a major yield reducing factor in calcareous soils in the upper northern plains, primarily affecting soybean [*Glycine max* (L.) Merr]. Determining the cause and location of IDC on a given year is difficult to predict due to several soil and weather variables occurring in this region. Minimal research has been conducted on whether residual preemergence herbicides play a role in amplifying the severity of IDC in soybean. As preemergence herbicides become more important in soybean, it is important to ensure proper weed control without stressing the crop and amplifying underlying issues leading to increased yield loss. The objectives for this study were to compare preemergence herbicide active ingredients on their IDC efficacy, measure certain IDC characteristic symptomology after application, and determine if there is amplified IDC activity based on symptoms and yield data. This experiment was conducted in four locations in Prosper, Arthur, and Hillsboro, North Dakota as well as Glyndon, Minnesota. Data collection consisted of visible IDC rating (1-5), SPAD (soil plant analysis development), which measures chlorophyll levels in the plant, Canopeo, and yield (kg ha^{-1}). The experimental design was an RCBD with 4 replications. Herbicide treatments consisted of a commercial premixture of pyroxasulfone & imazethapyr & saflufenacil as well as a commercial premixture which containing *S*-metolachlor & cloransulam-methyl & metribuzin. Each of these premixtures and their individual active ingredients were applied as separate treatments, resulting in eight herbicide treatments plus a weed free and weedy check. In Arthur, ND the SPAD levels indicated cloransulam-methyl alone had the highest chlorophyll content, while both premixtures and imazethapyr resulted in less chlorophyll than the other herbicides. At Prosper the weedy check had the highest chlorophyll content, while imazethapyr resulted in the lowest. Hillsboro, ND was chosen as a check site as IDC does not occur at the location. The weedy check had the highest chlorophyl content, however, the weedy check resulted in significantly lowest yield compared to all other treatments. During the 2025 season in Glyndon, MN, IDC was severe throughout the plot and resulted in complete stand loss after the first SPAD recording. In the only SPAD rating of 2025, the premixture of pyroxasulfone & imazethapyr & saflufenacil recorded the lowest chlorophyll measurements and was near the bottom in the 2024 field season behind only cloransulam-methyl. The overall findings indicated a pattern of the premixture pyroxasulfone & imazethapyr & saflufenacil as well as imazethapyr alone at the first SPAD rating (28 to 42 DAP) resulted in lowest chlorophyll levels across both field seasons at Prosper and Arthur, ND. In Glyndon, MN, the premixture of pyroxasulfone & imazethapyr & saflufenacil as well as cloransulam-methyl alone, resulted in the lowest chlorophyll levels. However, these treatments did not result in significant yield loss compared to most other treatments. At this time, growers should focus on other mitigation factors like tolerant cultivars, improving soil conditions, and the use of chelate technology to combat IDC symptoms and continue using a preemergent herbicide program that fits their weed control needs.

123 - How Variable Application Rates of Soil Residual Herbicides Alter Solution Availability in Nonuniform Field Soils

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Soil residual herbicides applied at full rates are key components of best management practices recommended for herbicide-resistant weed species. The premise is that full application rates will extend the persistence of plant available herbicide in the soil for more robust soil residual activity. The concept of optimizing soil residual herbicides using precision application equipment is based on fields containing non-uniform soils that require variable herbicide application rates. Therefore, the purpose of these experiments was to evaluate solution herbicide availability in nonuniform field soils after variable rate application of soil residual herbicides. Field and lab experiments were established in 2023 and 2024 to quantify the concentrations of herbicides in soil solution following variable rate application of soil residual herbicides based on label recommendations in fields with high soil variability. Previously mapped soil management zones within the field test sites include Medium <3%, Medium >3% OM, Fine <3%, and Fine >3% OM. Clopyralid and flumetsulam were applied at three combined rates, 87 to 174 and 33 to 65 g ai ha^{-1}, respectively. Cloransulam-methyl and sulfentrazone were applied at four combined rates, 18 to 42 and 175 to 420 g ai ha^{-1}, respectively. Concentrations of total and solution available herbicide were used to determine the percentage of available herbicide across soil management zones at variable application rates. Clopyralid solution availability was not different across soil management zones, while flumetsulam partitioned twice as much herbicide to soil solution in the Medium <3% OM management zone compared to other soil management zones. Conversely, sulfentrazone solution availability was 10% greater in the Fine >3% OM management zone, attributed to a higher soil pH (> 6.5) compared to other soil management zones. The Medium <3% OM management zone partitioned 10% of the total cloransulam-methyl to solution compared to 5% in the >3% OM management zones. Solution

availability of cloransulam-methyl, flumetsulam, and sulfentrazone were all positively correlated to pH of the soil, with sulfentrazone having the strongest significant correlation in 2023 (r = 0.54, P = <0.001) and 2024 (r = 0.59, P = <0.001). Findings from these studies suggest soil pH should be included in soil management zone delineation when ionizable residual herbicides are used to achieve consistent solution availability with variable rate application. Additionally, solution herbicide availability involves numerous biotic and abiotic factors; consistent solution concentration differences may be more prevalent as the diversity of soil conditions widens with a broader geographical scale.

124 - Influence of Glufosinate Application Timing, Rate, and Mixtures on Glufosinate-Resistant Soybean

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Weed management in soybean is complicated by problematic weeds with resistance to multiple herbicide modes of action, leaving growers with limited options for sufficient in-season chemical weed control. With a pronounced increase in planting soybean with glufosinate resistance, postemergence applications of glufosinate have been for broad spectrum control of weeds, including those with multiple herbicide resistance. The wide germination period during the growing season for weeds such as waterhemp, and potential weed escapes from previous herbicide applications, has driven commercial applications of glufosinate to extend into reproductive growth stages of soybean. Although, glufosinate product label restrictions limit applications in glufosinate-resistant soybean to the vegetative growth period of soybean. Currently, no published literature on the soybean grain yield impact from these late glufosinate applications is available. Thus, our research objective was to investigate yield impact of glufosinate applications ranging from late vegetative growth to late reproductive growth stages of glufosinate-resistant soybean. A multistate field trial was conducted as a randomized complete block design with four replicates and two experimental factors: application timing and glufosinate rate. Glufosinate was applied at 370 g ai ha^{-1} or 448 g ha^{-1} at the V5-V6 growth stage and each reproductive growth stage from R1 through R5. Prior to these applications, plots were kept weed-free by using non-injurious pre-emergent herbicides. Visual crop injury ratings were evaluated at 7, 14, 21, and 28 days after each application timing. At maturity, a total of 1 m^2 section from the center two plot rows were collected. For each soybean plant, the number of pods at each node were counted, plants were threshed, and total seeds weighed. Weight per 100 seeds was also measured. The plots were then harvested at maturity to determine yield. Harvest index metrics and plot yield were analyzed to determine the influence of glufosinate rate and application timing. Yield data from Arkansas, Indiana, North Dakota, Ohio, and Wisconsin did not demonstrate an influence of glufosinate application timing on soybean grain yield. However, applicators must be mindful of label restrictions and potential residues of glufosinate in grain.

125 - The Interaction of Diflufenican and Metribuzin on Soybean Response and *Amaranthus* Control

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Diflufenican, a phytoene desaturase-inhibiting herbicide (HRAC Group 12), is being developed for soil residual weed control and represents a new herbicide mode of action for U.S. soybean production. Although diflufenican will likely be commercialized as a solo product, best management practices recommend use in tank mixtures to enhance weed control and reduce selection pressure for herbicide resistance. Metribuzin, a photosystem II-inhibiting herbicide (HRAC Group 5), is commonly used in soybean production and provides soil residual activity on small-seeded broadleaf weeds such as the *Amaranthus* species. Field experiments were conducted in 2024 and 2025 to evaluate the preemergence activity of diflufenican on Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus*) applied alone and in combination with metribuzin. Trials were established on a silt loam soil (Lafayette, IN) and a loamy sand, high organic matter soil (Winamac, IN). Metribuzin rates were adjusted according to soil type, and diflufenican rates were selected to maintain an approximate 2:1 metribuzin to diflufenican ratio. Visual crop injury and weed control estimates were recorded at 14, 21, 28, and 42 days after application (DAA). Weed counts were collected at 28 and 42 DAA. Diflufenican applied alone had approximately 40% control of Palmer amaranth at 28 DAA, while mixtures of diflufenican and metribuzin resulted in 70-85%, depending on metribuzin rate. At Lafayette, control of waterhemp from diflufenican alone was generally greater than with Palmer amaranth at Winamac, likely due to differences in soil properties and weed emergence patterns. In 2025, control of waterhemp at 28 DAA from diflufenican alone was 85% while tank mixtures with metribuzin had 80-90% control. Colby’s method indicated primarily additive interactions between diflufenican and metribuzin, with no evidence of synergy. Across all site-years, soybean injury remained <10%, with no stand loss observed. These results demonstrate that diflufenican mixtures with metribuzin could serve as an effective component of integrated weed management programs targeting *Amaranthus* species in soybean production systems.

126 - Does the Absence of Atrazine Target-Site Resistance Reduce Concerns When Using Metribuzin to Control Problematic Indiana Waterhemp Populations?

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Atrazine resistance in waterhemp (*Amaranthus tuberculatus*) can occur through target site resistance (TSR) via the Ser-264-Gly mutation or non-target site resistance (NTSR) mediated by GSTs. The TSR mutation results in high level resistance to atrazine applications applied PRE or POST, as well as other HRAC group 5 herbicides. Alternatively, NTSR does not confer resistance to all group 5 herbicides, with the activity of metribuzin preserved. Therefore, discerning the frequency of TSR vs. NTSR for atrazine in Indiana waterhemp populations would serve as the basis for understanding the utility for metribuzin for waterhemp management. Our research objective was to screen problematic Indiana waterhemp

populations for atrazine and metribuzin resistance, as well as identify the resistance mechanism(s) and their frequency within the resistant populations. Greenhouse research was conducted on 60 problematic Indiana waterhemp populations that previously survived field and greenhouse applications of 2,4-D and dicamba. Positive and negative waterhemp controls included two atrazine sensitive populations, one NTSR population, and one TSR population. Herbicide treatments included no herbicide, atrazine (1,121 and 3,363 g ai ha^{-1}), and metribuzin (525 and 1575 g ai ha^{-1}). All herbicide applications included crop oil concentrate at 1% v/v and were performed when the waterhemp plants reached 8-10 cm in height. Visual control estimates were then recorded 7 and 14 days after treatment (DAT). At 14 DAT, leaf tissue samples for molecular analysis were collected from plants that displayed ≤ 85% visual injury from either rate of metribuzin. Out of the 60 populations, 59 had at least 1 plant survive (≤ 95% visual control) the high rate of atrazine, providing evidence that nearly all populations contained some frequency of atrazine-resistant individuals. Furthermore, the high rate of atrazine resulted in 4 populations with a survival frequency similar to the TSR control and 32 populations similar to the NTSR control. Out of the 60 populations, 56 had at least one plant survive (≤ 95% visual control) either rate of metribuzin. The Ser-264-Gly mutation was not present within any plants that had ≤ 85% control from the metribuzin application at either rate. The absence of the TSR mutation suggests that NTSR is the predominant mechanism of atrazine resistance in Indiana, and that metribuzin is still a viable management tactic. Although the number of populations with individual plants surviving metribuzin suggests that waterhemp adaptations may exist that allows survival to post-emergence metribuzin applications. Further research will be conducted to more completely characterize the metribuzin dose response for populations that survived metribuzin applications in this initial screen.

127 - Accounting for pH and Salinity: A Deeper Look into Weed Seed Suppression with Black Soldier Fly Compost Tea

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Black soldier fly (*Hermetia illucens*, BSF) frass represents a sustainable byproduct of insect agriculture with potential applications in integrated weed management. Previous research demonstrated that compost tea derived from BSF frass suppressed weed seed germination in a dose-dependent trend across multiple species. However, the mechanisms responsible for this phytotoxicity remained unclear. Two experiments were conducted in growth chambers at Purdue University, West Lafayette, IN in 2025 to determine whether pH or electrical conductivity (EC) were responsible for weed seed germination inhibition from BSF frass tea. In both experiments, eight BSF frass tea concentrations ranging from 0 (deionized water control) to 0.20 g BSF frass mL^{-1} of water were tested. In the first experiment non-buffered BSF frass tea (pH 4.5 to 5.5) was compared with the same doses of BSF frass tea neutralized to pH 7.0 with the addition of sodium hydroxide. In the second experiment BSF frass tea was compared with sodium chloride solutions that matched EC values at each BSF frass tea concentration. In both studies 3 ml of treatment solution was placed into a petri dish containing a piece of filter paper and 20 seeds of either redroot pigweed (*Amaranthus retroflexus* L.), barnyardgrass (*Echinochloa crus-galli* [L.] P. Beauv.), or velvetleaf (*Abutilon theophrasti* Medik.). Growth chambers were set to a 14-hour photoperiod (30/18 C day/night). Both experiments consisted of two experimental runs, each with three replications arranged in a completely randomized design. At 7 and 14 days after treatment, germination, defined as radicle emergence exceeding 1 mm, was assessed. Data were analyzed separately for each weed species using a three-parameter log-logistic dose-response models (LL.3), and EC_{50} values were calculated for each frass tea. Analysis of variance and t-tests compared EC_{50} values between both studies. In the first experiment, neutralizing the pH of BSF frass tea did not significantly reduce its inhibitory effects for any weed species tested. In the second study, BSF frass tea was significantly more suppressive than EC-matched salt water solutions for all species across all doses: pigweed (5.2% vs 11.9% germination, respectively), barnyardgrass (46.5% vs 65.5% germination, respectively), and velvetleaf (8.5% vs 20.7% germination, respectively). In conclusion, these findings suggest that BSF frass tea contains water-soluble weed seed germination-suppressive properties independent of pH or electrical conductivity.

128 - Residual Activity of Preemergence Herbicides for Weed Control in Corn and Soybean

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The widespread occurrence of herbicide-resistant weeds, combined with increasingly variable weather that limits postemergence (POST) herbicide efficacy, underscores the importance of robust preemergence (PRE) herbicide programs in corn and soybean. Evaluating the persistence of PRE herbicides is critical for scheduling timely POST applications and developing integrated management strategies. Therefore, field study was conducted at Curtiss Farm, Iowa in 2025, to evaluate the duration of PRE weed control provided by various corn and soybean herbicides. The experiment was arranged in randomized complete block design with four replications and an untreated control. PRE treatments for corn consisted of acetochlor + flumetsulam + clopyralid (1,748 g ai ha^{-1}), bicyclopyrone + mesotrione + s-metolachlor + pyroxasulfone (2,169 g ai ha^{-1}), atrazine + bicyclopyrone + mesotrione + s-metolachlor (2,892 g ai ha^{-1}), pyroxasulfone + saflufenacil (200 g ai ha^{-1}), acetochlor + mesotrione + clopyralid (2,742 g ai ha^{-1}), atrazine (2,242 g ai ha^{-1}), mesotrione (270 g ai ha^{-1}), s-metolachlor (2,141 g ai ha^{-1}), dimethenamid-P (1,103 g ai ha^{-1}), pyroxasulfone (183 g ai ha^{-1}), and clopyralid (282 g ai ha^{-1}). Soybean PRE treatments included s-metolachlor (2,141 g ai ha^{-1}), pyroxasulfone (183 g ai ha^{-1}), acetochlor (1,681-3,923 g ai ha^{-1} depending on formulation), flumioxazin (105 g ai ha^{-1}), metribuzin (841 g ai ha^{-1}), s-metolachlor + metribuzin (2,732 g ai ha^{-1}), flumioxazin + pyroxasulfone (200 g ai ha^{-1}), s-metolachlor + fomesafen (2,223 g ai ha^{-1}), metribuzin + sulfentrazone (630 g ai ha^{-1}), pyroxasulfone + sulfentrazone (420 g ai ha^{-1}), and imazethapyr + saflufenacil + pyroxasulfone (215 g ai ha^{-1}). All herbicides were applied at planting using a CO_2-pressurized backpack sprayer equipped with TTI110015 flat-fan nozzles, calibrated to deliver 140.3 L ha^{-1} at 241.3 kPa. Weed control was visually rated 45 days after treatment (DAT) on a 0-100% scale (0 = no control; 100 = complete control). Data were analyzed using ANOVA, and treatment means were separated with Fisher's LSD test ($\alpha = 0.05$). Statistical analyses were performed in RStudio (version 4.5.2). For waterhemp (Amaranthus tuberculatus (Moq.) J. D. Sauer) control in corn, all herbicide premixes provided 88-99% control, while single-site-of-action (SOA) herbicides achieved 30-74% control, except acetochlor, with 97% waterhemp control. For common lambsquarters (*Chenopodium album* L.), herbicide premixes, acetochlor and atrazine alone maintained 91-99% control, compared to single site of action (SOA) herbicides, which resulted in 36-67% control. In soybean, most PRE herbicides maintained 91-99% giant foxtail (Setaria faberi Herrm.)]. control at 45 DAT; however, flumioxazin, metribuzin, and premix containing metribuzin + sulfentrazone showed reduced activity (70-74%). For common ragweed (Ambrosia artemisiifolia L.), all the PRE herbicides provided 91-100% control at 45 DAT, except for premixes containing metribuzin + sulfentrazone (66%), s-metolachlor (76%), and acetochlor (82%). No visual crop injury was observed in either crop. These findings demonstrate that PRE herbicides with multiple sites of action provided more consistent and extended weed control than single-SOA products in conventional tillage corn and soybean systems, thereby reducing the pressure on early postemergence applications and supporting season-long weed management strategies.

129 - Evaluating Cereal Rye Termination Timing, Nitrogen Application Timing, and Herbicide Programs in Corn Production

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With the rise of herbicide resistance in weeds, corn (*Zea mays* L.) production has come under threat in Ohio. Diversifying management options, including integrated pest management (IPM), has become a popular method to help combat the issue of herbicide resistance. IPM strategies include the use of cover crops to help manage resistant weeds. In the Midwest, cereal rye is the most commonly used cover crop. "Planting green," (PG) or terminating the cover crop after the cash crop has been planted, is a growing trend utilized to extend ground cover time and to potentially reduce weed emergence and growth. Historically, PG has only been recommended for use in soybean production; however, growers in Ohio have been experimenting with PG in corn. To help understand the impacts of PG in corn, a study was conducted at two locations in Ohio to evaluate the effects of this practice in corn production and weed management. The objectives of this study were to determine the effects of: 1) termination timing of the rye cover crop (14 days before planting corn and at the time of planting corn); 2) nitrogen application timing (pre-plant, 50/50 pre/post plant, after planting); and 3) herbicide program (atrazine and atrazine + s-metolachlor + mesotrione + bicyclopyrone) on weed size and density, and corn stand, ear leaf N at R1, and yield. The experimental design was a fully factorial randomized complete block design with three factors and 12 treatments. In 2024, the late termination timing at the Western location reduced henbit (*Lamium amplexicaule* L.) and dandelion (*Taraxacum officinale* F. H. Wigg.) density relative to the early termination timing; however, the purple deadnettle (*Lamium purpureum* L.) density in the early termination timing was lower than the late termination timing. In 2025, the late termination timing at the western location reduced giant foxtail (*Setaria faberi* Herrm.), giant ragweed (*Ambrosia trifida* L.), and prickly sida (*Sida spinosa* L.) density relative to the early termination timing. At the Northwest location, the split- and post-applications of N showed a 0.25% and a 0.41% increase in N levels, respectively, in corn ear leaf samples at R1 relative to the PRE-application. In 2025, the corn at the western location showed that the split and pre-plant N application timing had lower amounts of N than the post-plant application, but the northwest location had no difference. In 2024, the corn yields for both locations were influenced by pest damage. In 2025, at both locations yield was not influenced by the treatment factors.

The data from this study illustrates that the later termination of a rye cover crop when planting green systems for corn can reduce the size and density of weeds, but that comprehensive herbicide programs and timely N applications are still critical for crop production and weed management.

130 - Weed Control and Crop Safety of Winter Wheat Residual Herbicides Prior to Double-Crop Soybeans

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Effective spring weed control in winter wheat is critical for maximizing double-crop soybean productivity in Kansas cropping systems. Persistent challenges at wheat harvest are pigweed species, such as waterhemp (*Amaranthus tuberculatus*) and Palmer amaranth (*Amaranthus palmeri*) as well as annual grasses. A field study was conducted in 2025 at three locations across eastern Kansas (Manhattan, Rossville, and Ottawa) to evaluate pre-emergence herbicides applied in the spring for weed control efficacy and soybean crop response to both STS and non-STS soybean varieties. Herbicides included full and half labeled rates for wheat of chlorsulfuron, flucarbazone, imazamox, metribuzin, metsulfuron, pyroxasulfone, pendimethalin, propoxycarbazone, and sulfosulfuron, along with weedy and weed-free controls. Four 76 cm-row plots were arranged in a split-plot design with four replications at each site, and each plot having two rows of each soybean variety. The entire experiment started clean with burndown applications of 2,4-D plus glyphosate. No-tillage bare ground pre-emergence herbicides were applied in the spring, approximately two months prior to soybean planting in early July. Weed density and biomass of pigweed species and annual grasses were recorded up to soybean planting. The entire area received a burndown application at soybean planting of glyphosate plus glufosinate. To assess crop safety with pre-emergence products, soybean stand, height, nodes, and biomass were recorded at R1 growth stage, and soybean yield harvested. In the weedy control, Palmer amaranth densities at Manhattan and Rossville were 40 and 8 plants m^{-2}, respectively, compared to 71 plants m^{-2} of waterhemp at Ottawa. Across locations, treatments containing pyroxasulfone and metribuzin provided the most consistent pigweed control, resulting in the lowest density and biomass. Pendimethalin provided moderate pigweed suppression but was generally less effective than pyroxasulfone and metribuzin. ALS-inhibiting herbicides (including flucarbazone, metsulfuron, propoxycarbazone, chlorsulfuron, imazamox, and sulfosulfuron) resulted in poor pigweed control. Grass pressure was relatively low at Manhattan and Rossville but higher at Ottawa. Under these conditions, pyroxasulfone and pendimethalin resulted in the lowest biomass and density of annual grasses, followed by sulfosulfuron and chlorsulfuron. In general, STS soybean was taller overall compared to non-STS soybean. Crop injury was only observed in plots with chlorsulfuron at the full labeled rate in non-STS soybean, resulting in shorter plants with less biomass. Overall, pyroxasulfone and metribuzin programs provided the best balance of weed control and soybean crop safety across environments. These results suggest that pyroxasulfone and metribuzin remain effective components for integrated weed management in wheat to double-crop soybean systems.

Student Contest – Weed Genetics & Herbicide Physiology / Weed Biology & Ecology

131 - Harnessing Big Data from Model Species for Cis-Regulatory Annotation in Non-Model Plants via Transfer Learning

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[1]Michigan State University, [2]BASF

Gene regulation plays a central role in plant stress resistance. While large-scale omic databases have provided valuable insights into regulatory mechanisms, they are predominantly limited to model species. Recent advances in deep learning now enable the transfer of regulatory knowledge from model species to related non-model species. Here, we present a framework that processes public omic data from model plants, fine-tunes an existing deep learning model, predicts regulatory landscapes in related species lacking such data, and annotates gene regulatory features from the resulting predictions. Our results demonstrate that this approach produces accurate regulatory inferences, and we anticipate prediction accuracy will continue to improve as additional public omic datasets become available for model retraining and expansion.

132 - What Is the Impact of a Changing Climate on the Geographic Distribution of Giant Ragweed?

Datta Chiruvelli[1], Ryan Briscoe Runquist[1], David Moeller[1], Roger Becker[1], Amit Jhala[2], Debalin Sarangi[1]

[1]University of Minnesota, [2]University of Nebraska

Changing climate is impacting ecosystems and ecological communities, leading to shifts in phenology, geographic ranges, or population sizes of many species. As a result, predicting how climate change will affect the current and future distribution of weed species is a crucial research question. Giant ragweed (*Ambrosia trifida* L.) is a summer annual weed native to North America that has spread from riparian zones into agricultural fields, reducing crop yields and impacting human health through allergenic pollen. To identify the climatic factors influencing its distribution and to predict potential range shifts under climate change, species distribution models (SDMs) were developed using MaxEnt and boosted regression trees (BRT). Occurrence records from the Global Biodiversity Information Facility (GBIF) and EDDMapS were spatially filtered to 1,442 unique points. Five key bioclimatic variables, such as Isothermality (Bio3), Mean Temperature of the Warmest Quarter (Bio10), Mean Temperature of the Coldest Quarter (Bio11), Precipitation Seasonality (Bio15), and Precipitation of the Warmest Quarter (Bio18), were selected from WorldClim at a 30-arc-second resolution. Both modeling approaches performed well (AUC > 0.90, TSS > 0.70) and accurately reflected the current distribution, mainly in the U.S. Midwest, the Great Plains, and southern Canada. Future projections using Coupled Model Intercomparison Project Phase 6 (CMIP6) climate models (MIROC6 and CMCC-ESM2) under Shared Socioeconomic Pathway 3-7.0 and 5-8.5 scenarios forecast a significant northward expansion of suitable

habitats by 2041-2060 and into the late century (2061-2080). Future distribution predictions show that the suitability of giant ragweed increased across the Upper Midwest and the Prairie Provinces of Canada, while it moderately decreased in parts of the southern Great Plains and the southeastern United States. Limiting-factor analysis showed that Bio 10 currently limits the northern range, whereas Bio 11 and Bio 15 increasingly limit the southern extent. Overall, models predict considerable northward expansion and moderate southern contraction, suggesting that *A. trifida* will likely invade cooler agricultural areas in the future. These projections highlight new invasion risks in northern North America and emphasize the need for proactive monitoring and adaptive management of giant ragweed.

133 - Identification of a Novel Clopyralid Detoxification Pathway in Clopyralid Resistant Ragweed (*Ambrosia artemisiifolia*)

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[1]Michigan State

Common ragweed (*Ambrosia artemisiifolia*) is a widely distributed annual weed that can cause significant yield losses if not properly controlled. Clopyralid (3,6-Dichloropyridine-2-carboxylic acid) is a Group 4 synthetic auxin used to control broadleaf weeds including ragweed in several crops such as sugar beet and Christmas trees. A population of common ragweed (Ambel 40) was discovered to be resistant to a field rate of clopyralid. A greenhouse dose-response assay was conducted to determine the level of resistance, which found that Ambel 40 survived 64 times of the field rate of clopyralid. Given the high levels of resistance, we hypothesized that rapid metabolism may be the cause of resistance. The objectives of this research were to characterize the role of clopyralid metabolism in resistance and to identify clopyralid metabolites. A greenhouse dose response assay with malathion (Cytochrome P450 inhibitor) was conducted to determine whether malathion could reduce clopyralid resistance in Ambel 40. Pretreatment with malathion reduced the ED50 value from 52 times the field rate without malathion to 7 times the field rate with malathion. We then extracted and purified both clopyralid and its metabolites, identifying these metabolites and solving their structure by using high resolution mass spectrometry. We found that Ambel 40 rapidly converts clopyralid into 3 or 6-OH clopyralid which is then conjugated to glutathione. These results indicate that Ambel 40 evolved a novel clopyralid detoxification pathway where a potential cytochrome P450 preforms **oxidative dehalogenation** reaction followed by GSH conjugation performed by a GST. Further research is needed to identify and functionally validate potential P450s and GSTs responsible for clopyralid metabolism.

134 - Defining the Critical Period for Waterhemp Seedbank Management

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[1]University of Minnesota, [2]Colorado State University

The extended emergence period and high fecundity of waterhemp (*Amaranthus tuberculatus*) pose significant challenges to its management. Furthermore, the evolution and widespread occurrence of herbicide-resistant biotypes have complicated effective control of this species. Reducing seed production is essential for both immediate management success and the long-term sustainability of control strategies.

Field experiments were conducted in 2023 in Rosemount, MN, under non-crop (bareground) conditions and in soybean [*Glycine max* (L.) Merr], to determine the optimum timing for waterhemp seed control. The first experiment, the critical period of waterhemp emergence (CPWE), quantified viable seed production from the plants that emerged at different timings throughout the growing season. The second experiment, the critical period of waterhemp seed production (CPSP), assessed viable seed production from early-emerging plants harvested at sequential intervals after the onset of flowering. For both experiments, viable seed production was expressed as the percentage of the maximum observed viable seed production, and data were analyzed using nonlinear regression models. Flowering in waterhemp occurred slightly earlier when competing with soybean than in bareground conditions. The earliest emerging plants produced the highest number of viable seeds, averaging 64,000 and 156,000 viable seeds plant^{-1} in soybean and bareground, respectively. To restrict viable seed production to below 5% of maximum levels, waterhemp should be controlled between 482 and 1,135 cumulative growing degree days (cGDD) in soybean and between 945 and 1,163 cGDD in bareground conditions. Additionally, waterhemp plants shed approximately 18.5% of their total seeds at soybean harvest. To our knowledge, this is the first study to define the critical period for seed control in any weed species, providing a valuable framework for future research and management strategies.

135 - Confirmation and Transcriptomic Characterization of Glufosinate-ammonium Resistance in Waterhemp (*Amaranthus tuberculatus*) Populations from Illinois

Cristiana Bernardi Rankrape[1], Isabel Werle Noe[2], Logan Miller[2], Eduardo Lago[1], Rishabh Singh[2], Alexander Lopez[2], Aaron Hager[2], Karla Gage[1], Patrick Tranel[2]

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The use of glufosinate-ammonium (GA) has increased substantially across the United States over the past decade, largely due to the widespread adoption of GA-resistant crops. Most of the GA applications have been concentrated in the Midwest and Southern regions, where soybeans and corn are the most prevalent crops. Waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer) is a predominant weed in these crops and has evolved resistance to herbicides spanning multiple sites of action (SOAs), but not yet to GA. However, increased reliance on GA has intensified selection pressure, and inconsistent waterhemp control following GA applications has been frequently reported in recent years. This study evaluated the reduced GA sensitivity in four Illinois waterhemp populations (CAR, SDY, M01, and FRA). Whole-plant dose-response assays were conducted twice in a completely randomized design with eight GA rates (0-1,580.7 g ai ha^{-1}; Liberty® Ultra) plus ammonium sulfate (2.5% v/v). Plants (7.5-10 cm) were sprayed in a chamber equipped with an 80015 EVS nozzle delivering 187 L ha^{-1} at 207 kPa. At 21 days after application (DAA), survival and dry biomass were recorded and subsequently analyzed using log-logistic regression models using *drc* package in RStudio. To evaluate the response to GA under field conditions, a field study at the CAR site evaluated waterhemp response to GA applied at seven rates (0-5,936 g ai ha^{-1}; Liberty® Ultra). To assess resistance to other herbicides SOA, greenhouse screenings evaluated the response of all four suspected-resistant populations to 2,4-D, atrazine, fomesafen, glyphosate, lactofen, paraquat, and imazethapyr at 0.5×, 1×, and 3× field-labeled rates. To investigate potential mechanisms underlying reduced GA sensitivity, transcriptomic analyses were performed on plants from the four suspected-resistant populations and two GA-susceptible populations (WUS, BRC). Results indicated

resistance ratios ranging from 2.1- to 3.4-fold based on survival and 1.3- to 2.8-fold based on dry biomass across populations relative to WUS. Results from the field dose-response trial at the CAR site corroborated greenhouse findings, with some plants surviving the recommended GA field rate. All four populations exhibited reduced sensitivity to atrazine, glyphosate, and imazethapyr, and to a lesser extent, to lactofen and fomesafen. No resistance-associated mutations or differential transcript abundance was detected in plastidic or cytosolic glutamine synthetase genes. However, 182 genes were differentially expressed among resistant populations relative to susceptible populations, with one gene being shared across all resistant populations. Many of the upregulated genes identified, including cytochrome P450s, glutathione *S*-transferases, glycosyltransferases, transporters, and transcriptional regulators, are commonly associated with metabolic resistance. These findings provide initial evidence for GA resistance evolution in waterhemp populations in Illinois and suggest a predominantly metabolic, rather than target-site, mechanism of resistance. More research is ongoing to characterize the heritability of the resistance trait.

136 - Weed Seed Survival and Germination in Simulated Chaff Lines

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[1]The Ohio State University

Long-term management of troublesome weeds can be improved by reducing inputs to the weed seed bank. Harvest weed seed control (HWSC) is one strategy that can reduce weed seed bank density. Chaff lining, a HWSC practice in which chaff is arranged in a narrow windrow, concentrates weed seeds into a smaller area. This may create a less favorable germination environment and allow for more targeted weed management practices. Seed survival in chaff lines was evaluated over the winter of 2024-2025 winter in simulated chaff lining flats. Each flat contained 500 weed seeds, soilless media, and one of six chaff levels representing different soybean yields: 0 kgha^{-1} chaff (control), 1345 (20 bu/ac soybeans), 2690 (40 bu/ac), 4035 (60 bu/ac), 5380 (80 bu/ac), and 6725 kgha^{-1} chaff (100 bu/ac). Four weed species were included in this study: waterhemp (*Amaranthus tuberculatus* [Moq.]), giant ragweed (*Ambrosia trifida* [L.]), giant foxtail (*Setaria faberi* [Hermm.]), and yellow foxtail (*Setaria pumila* [Poir.]). Flats overwintered in ambient environmental conditions in a field at Waterman Farm in Columbus, Ohio before being moved into the greenhouse in mid-March. Germination counts were conducted twice weekly, and any additional weed species that emerged were also recorded. Data were analyzed in RStudio using the tidyverse, multcompView, ggplot2, dplyr, car, and patchwork packages. Normality was assessed, and species emergence data were analyzed using an ANOVA with the aov() function. Across all four species, germination was not significantly reduced by any amount of chaff, though no species reached full germination rates of 100 percent. These results suggest that the range of chaff weights tested did not create a sufficiently inhospitable environment to limit seed germination under these conditions. These results also show that weed seed germination rates are variable among species, even after being allowed to overwinter in an outdoor setting. Yellow foxtail and waterhemp were the only two species for which approximately 60 percent germinated. This trial is being repeated over the 2025-2026 winter to further evaluate the effects of chaff lining on weed seed survival. This study is also paired with a chaff lining field study at the Western Agricultural Research Station in South Charleston to better understand the utility and value of HWSC in Ohio.

137 - Development of KASP Assays to Differentiate between Sorghum bicolor, halepense, and their Hybrids: Insight into Crop-to-Weed Gene Flow

Connor Purvis[1], Eric Patterson[1], Erin Burns[1]

[1]Michigan State University

Johnsongrass (*Sorghum halepense*) is a troublesome weed that causes environmental and economic damage worldwide. Johnsongrass is a tetraploid, thought to be formed from the hybridization of the annual diploid, *Sorghum bicolor*, cultivated sorghum or shattercane and a wild perennial diploid species, *Sorghum propinquum*. Hybridization of johnsongrass and cultivated sorghum can occur in the field, leading to offspring that are difficult to identify morphologically. To date, there is no genetic marker to differentiate between *S. bicolor*, *S. halepense*, and their hybrids. Therefore, the objective of this study was to create a genetic assay that accurately distinguishes each species and their hybrids. To accomplish this, we developed a kompetitive allele specific PCR (KASP), a method that is commonly used to quickly and cheaply distinguish samples by a single nucleotide polymorphism (SNP) in breeding. An analysis of the internal transcribed spacer (ITS) region revealed a single SNP that differentiated these species consistently in all NCBI submissions. Using this SNP, species-specific primers were designed and labelled with 5' fluor-labeled oligos of either the FAM (*S. bicolor*) or HEX (*S. halepense*) fluorophores. A cultivated sorghum line (Rtx430) and a known *S. halepense* biotype were used as positive controls. Additional PCR primers were designed to amplify the entire ITS region for Oxford Nanopore sequencing for direct confirmation of the FAM/HEX KASP results. The positive controls of each species were crossed in the greenhouse as positive controls for F_1 hybrid formation and detection. The resulting F_1 seeds, 67 USDA *S. bicolor,* and 79 *S. halepense* collections were subjected to the KASP assay. Pearson's correlation was conducted on arctan transformed KASP (FAM/HEX) and Oxford Nanopore outputs to cross-validate KASP results. Our data shows that the KASP assay performs as well as Nanopore sequencing for measuring SNP frequency and there is a perfect proxy for genotyping *S. bicolor*, *S. halepense*, and their hybrids ($R^2 = 0.97$, p-value = <0.001). Greenhouse crosses revealed striking differences in hybrid formation, with *S. halepense* being more receptive of foreign pollen than *S. bicolor*; no hybrids were formed when *S. bicolor* was the female; however, when *S. halepense* was the female, 67% of individuals were hybrids. In the USDA collection, 97% of biotypes were assigned *S. bicolor*, while 3% were assigned as hybrids using the KASP assay. Naturally collected unknown biotypes showed a wide range of hybridization with 59% assigned *S. halepense*, 4% *S. bicolor*, and 37% as hybrids. Overall, we created a genetic assay that can identify *S. bicolor, S. halepense,* and their hybrids. Our greenhouse crosses show crop-to-weed gene flow, a potentially large concern for *Sorghum* breeding programs where the ranges of both species overlap. Additionally, some of the known USDA germplasm biotypes seem to be misidentified, highlighting the difficulty in correctly identifying these species and their hybrids morphologically and the frequency of hybrids in the wild. Future work will aim to differentiate between hybrids and assess their competitiveness in comparison to parental biotypes.

138 - Confirming Group 15 Herbicide Resistance in a Giant foxtail (*Setaria faberi*) 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 in 2024 and 2025 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, 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, 1x, and 2x rates of acetochlor and dimenthenamid-P did not reduce density or biomass while the 2x and 4x rates 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 or biomass compared with the nontreated control. No treatment provided greater than 70% control 28 days after application. Accumulated rainfall within 28 days after application totaled 11 and 5 cm in 2024 and 2025, respectively. 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. The sensitive population was completely controlled at 507 g ai/ha S-metolachlor whereas the putative resistant population required 5,440 g ai/ha for complete control. Collectively, these field and greenhouse results demonstrate greatly reduced sensitivity of a giant foxtail population to Group 15 herbicides.

139 - Expression of HPPD and CYP genes in Triketone- Resistant Transgenic Wheat

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Weed infestation is the major factor contributing to reduced wheat yields. Repeated use of herbicides led to evolution of herbicide resistant weed species. Currently, herbicide-resistant wheat technologies are limited. Therefore, broadening herbicide options for weed management is needed. Hydroxyphenylpyruvate dioxygenase (HPPD)- inhibitor herbicides provide broad spectrum of weed control. However, they are not registered for weed control in wheat due to crop injury concerns. Previous reports suggest metabolic resistance *via* Cytochrome P450 enzyme activity is reported in corn. Additionally, alteration of the molecular target of these herbicides, i.e., the HPPD gene provided resistance to triketones in soybean. With this data, previously we developed callus derived T_0 transgenic wheat lines through transformation *via* particle bombardment, resistant to HPPD inhibitors with induced overexpression of genes *CYP81Q32*-like or *TaHPPD*. T_0 plants were regenerated and screened for the presence of gene of interest (GOI) and followed by screening in T_1 generation. This T_1 lines also displayed reduced sensitivity to mesotrione treatment. In this study, we aim to screen the overexpressed wheat gene *CYP81Q32*-like or *TaHPPD* gene targeting HPPD-inhibitors. We hypothesize that overexpression of these genes will reduce sensitivity to triketone herbicides in T_2 generation. Transgenic plants were selected and grown under controlled environment conditions. PCR analysis was conducted to confirm positive T_2 plants followed by mRNA transcript expression analysis using real-time quantitative PCR. Parallelly, Transgenics were phenotyped by spraying 6X (1X= 105 g ai ha^{-1}) dose of mesotrione**.** Visual injury percentage (VI) was recorded 3 and 4 weeks after treatment. These results suggested that plants overexpressed of the genes *CYP81Q32*-like or *TaHPPD* in transcript gene expression successfully reduced mesotrione sensitivity phenotypically in T_2 transgenic wheat, with a possibility of developing HPPD- inhibitor resistant wheat in the future.

140 - Validation of Agar-Based Dose-Response Assays for Herbicide Resistance Confirmation in Amaranthus tuberculatus

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The rapid evolution of herbicide resistance in waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer) across several modes of action is a growing concern. Thus, developing rapid diagnostic methods is essential for the early detection of herbicide resistance and to inform grower management decisions. Our study aimed to develop and validate an agar-based seedling dose response bioassay to detect waterhemp resistance to 2,4-D (1×:1065 g ae ha^{-1}), atrazine (1×:560 g ai ha^{-1}), fomesafen (1×:263 g ai ha^{-1}), mesotrione (1×:105 g ai ha^{-1}), and S-metolachlor (1×:1785 g ai ha^{-1}). The stock solutions (mg ai L^{-1}) of herbicides were diluted in liquid agar (0.6% w/v) to obtain the target treatment concentrations equivalent to 0.031× to 8× (logarithmic scale, x2 increment) the labeled rate for each herbicide plus a non-treated control (NTC). Twenty-five seeds were placed on the surface of the treated agar, and at 21 days after treatment (DAT), germinated and surviving seedlings were counted. Dose-response models were fitted to the data to estimate the effective dose causing 50% mortality (ED_{50}) and the resistance index (RI) relative to a susceptible accession. Initial results indicate that multiple resistance was observed for at least three accessions, with different modes of action, including 2,4-D and fomesafen. Agar-based assay results were strongly aligned with those of parallel greenhouse dose-response experiments. Findings from this study demonstrate that this is a promising method for investigating herbicide resistance in waterhemp.

141 - Using a Chlorophyll Fluorescence-Based Leaf-Disk Assay to Characterize the Bioavailability and Release Patterns of Encapsulated Saflufenacil

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Encapsulated herbicide formulations have long been explored as a way to enhance herbicide use patterns with the potential benefits of decreased volatility and increased handler and crop safety. Saflufenacil was recently reformulated as a microencapsulation and is labeled for preemergence and early postemergence applications in corn. Saflufenacil uses a novel solid encapsulation process that breaks open when the capsule dries and has trace levels of non-encapsulated herbicide present in the formulation. Although the encapsulation greatly decreases foliar absorption of saflufenacil, low levels of crop injury can still occur with foliar applications. A corn leaf disk assay was developed to assess the extent of free non-encapsulated saflufenacil in the commercial formulation and characterize the release of saflufenacil from the microcapsules. To evaluate injury potential, the free saflufenacil fraction was physically separated by filtration from the encapsulated formulation. A treatment to induce the release of saflufenacil from the capsule was performed by allowing the encapsulated formulation to dry and then rehydrating the herbicide for plant uptake. The open-capsule treatment at 48 hours after treatment (HAT) resulted in the greatest reduction in photosynthetic efficiency (F_v/F_m) compared to the limited tissue damage from either the free saflufenacil extraction or full encapsulated formulation, which were similar for corn injury response. These results demonstrate greater corn injury from the open-capsule treatment, suggesting that the trace level of free saflufenacil in the encapsulated formulation product is the basis for the foliar corn injury rather than the saflufenacil in the microcapsules. Corn tissue damage, in the form of photosynthetic efficiency, was similar for the encapsulated saflufenacil formulation diluted at field application concentrations and stored for 0 to 7 days after mixing. Thus, the encapsulation of saflufenacil must be stable in aqueous solution over this time period since no difference in corn injury was exhibited from release of saflufenacil. Therefore, if postemergence applications of encapsulated saflufenacil must be delayed after mixing, neither compromised microcapsule stability nor increased corn phytotoxicity would be expected. However, this must be considered in combination with other factors outside of formulation stability that may impact the efficacy of a postemergence herbicide application, such as other herbicides, adjuvants, fertilizers, and water temperature or pH.

Student Contest – Horticulture & Specialty Crops / Equipment & Application Technologies / Cover Crops & Integrated Weed Management

142 - Evaluating Herbicide Options for Kernza® (*Thinopyrum intermedium*)

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Kernza (*Thinopyrum intermedium*) is the domesticated form of intermediate wheatgrass (IWG), bred as a dual-purpose grain and forage crop. As an emerging perennial grain, it offers a promising alternative to annual grain crops. Several studies on IWG have focused on plant breeding to improve forage yield, grain yield, and grain quality, thereby posing limited knowledge on herbicide options to maximize grain and forage production. Field experiments were conducted from 2023 to 2025 at the Rosemount Research and Outreach Center near Rosemount, Minnesota, to evaluate various herbicides applied in the fall and spring during the first year of IWG establishment. Herbicides were applied at 0.5×, 1×, and 2× the labeled rate for use in small grains. Weed control, crop injury, grain yield, and forage yield were assessed. The results showed that in 2024, spring-applied herbicides were more effective than fall application in terms of weed control, achieving 51% to 57% control. Among the fall-applied treatments, flucarbazone-sodium and *S*-metolachlor applied at 1× provided the highest weed control (≥ 36%) and reduced weed biomass substantially; however, *S*- metolachlor had a higher injury on IWG. Flucarbazone-sodium and pinoxaden showed the lowest injury on IWG when applied in the fall. All spring-applied treatments showed 51% to 57% weed control. Pendimethalin had 4% IWG injury, while pinoxaden caused the highest injury (23%). In both fall and spring applications in 2025, chlorsulfuron+metsulfuron methyl, metribuzin and sulfosulfuron at 1× and 2× showed highest broadleaf weed control, lowest weed biomass and minimal injury to IWG. Forage and grain yields were not impacted by herbicide treatments. Results from this study indicate that several herbicide options providing high weed control with minimal IWG injury are available.

143 - Does Cereal Rye and Reduced Tillage Influence Weed Management in Dry Edible Beans?

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[1]Michigan State University

Historically, dry bean production has been a tillage-intensive system, justified as the first and primary approach to weed management. As conservation tillage and cover crop practices have gained popularity for corn and soybean systems, there has been a lag in their adoption for dry bean systems. Some of the reluctance towards these practices is due to the potential negative impacts on weed control in dry beans. The objective of this research was to evaluate weed management strategies for dry bean that integrate cover crops and strip tillage approaches for weed control. A field experiment was established in 2025 at two locations: Michigan State University Agronomy Farm (MSU; East Lansing, MI) and Saginaw Valley Research and Extension Center (SVREC; Richville, MI). The experiment was designed as a split-plot randomized complete block design with cover crop as the main-plot (bareground, oats, and cereal rye), and herbicide program as the sub-plot factor. All treatments received a burndown application 15 d prior to planting with glyphosate (1.2 kg ae ha^{-1}), with one treatment including the addition of pendimethalin (1,060 g ha^{-1}) + dimethenamid-P (578 g ha^{-1}). Preplant herbicide treatments just before planting consisted of (1) no application, (2) pendimethalin + dimethenamid-P, (3) glyphosate, (4) glyphosate + pendimethalin + dimethenamid-P, (5) no application following the pendimethalin + dimethenamid-P (15 d earlier application). Strip-tillage and planting occurred immediately after preplant herbicide applications, followed by a POST application of dimethenamid-P (526 g ha^{-1}) + bentazon (733 g ha^{-1}) + imazamox (35 g ha^{-1}) + fomesafen (280 g ha^{-1}) across the entire study when weeds were ~5 cm tall. Cover crop dry biomass at termination was 1,593 and 11,135 kg ha^{-1} for oats and cereal rye at MSU and 2,357 and 7,093 g ha^{-1} at SVREC, respectively. The main effect of cover crop did not affect dry bean stands at SVREC; however, at MSU, stands were the highest in the bareground plots (18.9 plants m^{-1}), followed by oats (18.3 plants m^{-1}), and cereal rye (17.6 plants m^{-1}). Weeds were counted and biomass was harvested in-row (IR) and between rows (BR) prior to POST application. No differences in weed counts or biomass were present at SVREC. Weed counts IR and BR at MSU were lowest when pendimethalin + dimethenamid-P

was applied, with no differences between cover crops. At MSU, dry bean yield was highest with an oat cover crop, while bareground and cereal rye treatments resulted in an 11% reduction. The highest yields at SVREC were bareground, followed by oats and cereal rye with 7% and 15% reductions, respectively. Initial results from year one indicate that cover crops had no effect on weed counts or biomass; however, they did result in stand variation at MSU and yield differences at MSU and SVREC. This study will be replicated in 2026.

144 - Tolerance of Newly Planted Peppermint (*Mentha* x *piperita*) to Ethofumesate Under Greenhouse Conditions

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Peppermint (*Mentha* × *piperita* L.) is an economically important crop in the United States, widely cultivated for its essential oil used in the food, cosmetic, and pharmaceutical industries. Indiana is among the leading peppermint-producing states due to its favorable climate and soil conditions. However, weed competition during peppermint establishment can significantly reduce its growth and long-term oil yield potential, highlighting the need for effective and crop-safe herbicide options. As a result of this need, a dose-response trial was conducted in two experimental runs at the Purdue University Horticulture Greenhouses, West Lafayette, IN, in 2025, to determine the effect of ethofumesate on newly planted 'Redefined Murray Mitcham' peppermint. Two peppermint rhizomes (7 to 10 cm long) were planted per pot in 20-cm-diameter polyethylene pots and treated 1 day after planting with one of five ethofumesate rates: 0 (nontreated control), 1,260; 2,520; 5,050; or 10,100 g ai ha^{-1} . The experiment design was a randomized complete block with five replicates per experimental run. Data were collected at 1, 2, 4, 6, and 8 weeks after treatment (WAT) and included visible crop injury on a scale of 0% (no injury) to 100% (crop death) and crop height (5 shoots pot^{-1}). At 8 WAT the study was terminated; aboveground biomass was removed and dried to determine dry biomass. Plants were removed from their pots and root injury was recorded on the aforementioned 0 to 100% scale. All data were analyzed using R software. ANOVA was performed using the *car* package, and regression analysis was conducted to generate predictive models. At 2 WAT, peppermint injury increased from 24% to 79% and from 62% to 95% in Experimental Run 1 and 2, respectively, as ethofumesate rate increased from 1,260 to 10,100 g ai ha^{-1} . At 4 WAT, injury increased from 45% to 98% and from 16% to 94% in Experimental Run 1 and 2, respectively, as ethofumesate rate increased from 1,260 to 10,100 g ai ha^{-1}. At 6 WAT, injury increased from 18% to 97% (both experimental runs) as ethofumesate rate increased from 1,260 to 10,100 g ai ha^{-1}. By 8 WAT, injury increased from 23% to 100% and from 15% to 97% in Experimental Run 1 and 2, respectively, as ethofumesate rate increased from 1,260 to 10,100 g ai ha^{-1}. Pooled across both experimental runs, aboveground dry biomass of the nontreated check was 26.4 g pot^{-1} and decreased from 16.8 to 0.1 g pot^{-1} as ethofumesate rate increased from 1,260 to 10,100 g ai ha^{-1}. Despite necrotic and deformed leaf injury from ethofumesate at 1,260 g ai ha^{-1}, this rate resulted in only 4% root injury and in only a 17% reduction in plant height compared to the nontreated control. Results from this experiment suggest that ethofumesate applied at 1,260 g ai ha^{-1} may be useful in an integrated weed management program in peppermint, but further research is warranted to evaluate its potential risks and benefits.

145 - Influence of Tillage System and Herbicide Programs for Weed Control in Truvera Sugarbeet

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Strip tillage has been gaining popularity in row crow production due to benefits including reduced soil compaction, water conservation, and decreased erosion risk. While no-till systems offer strong soil conservation benefits, strip tillage also has the seedbed preparation advantages that come with conventional tillage. Adoption of strip tillage in sugarbeet production systems has been limited due to the lack of chemical weed control options that are needed in reduced tillage systems. The upcoming launch of Truvera sugarbeets will allow growers to use glyphosate, glufosinate, and dicamba in crop, expanding available herbicide choices. Therefore, research was conducted in 2025 in East Lansing and Frankenmuth, Michigan, to determine the influence of tillage system and herbicide program on weed control in Truvera sugarbeet. A split-split-plot randomized complete block design experiment was established with three factors and four replications. The main plot factor was tillage system, which had two levels: conventional or strip tillage. The sub-plot factor, preemergence (PRE) application, consisted of two levels: with PRE dicamba or without. 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. By 14 days after (DA) the 12 lf application, the interaction of PRE by POST herbicide program was significant for common lambsquarters (*Chenopodium album* L.) and horseweed (*Erigeron canadensis* L.) control. Dicamba PRE only controlled common lambsquarters 20%. All other herbicide programs controlled common lambsquarters 99%, regardless of the use of PRE dicamba. Including dicamba PRE improved horseweed control from 52 to 75% when three POST applications of glyphosate were made. The addition of glufosinate or dicamba in the POST applications controlled horseweed >91%. Only the main effect of POST herbicide program was significant for common chickweed (*Stellaria media* (L.) Vill.), henbit (*Lamium amplexicaule* L.), dandelion (*Taraxacum officinale* F.H. Wigg.) and velvetleaf (*Abutilon theophrasti* Medik.) control. Averaged over tillage system and PRE herbicide application, all POST herbicide programs provided 97% control of these species. Additionally, sugarbeet injury never occurred following any of the herbicide treatments. Sugarbeet stand was reduced up to 38% when no POST herbicide application was made, regardless of PRE, due to weed competition with the sugarbeet. The main effects of tillage system and POST herbicide program were significant for sugarbeet yield. Averaged over PRE and POST herbicide programs, sugarbeet yield was 2,300 kg ha^{-1} greater in strip tillage systems. Additionally, when averaged over tillage system and PRE treatment, up to a 20,200 and 6,700 kg ha^{-1} yield loss occurred when no POST was applied and when the POST consisted of three applications of glyphosate, respectively. Based on these findings, the use of Truvera sugarbeets can enable growers to use strip tillage while maintaining exceptional weed control, even for difficult to control winter annual weeds such as glyphosate-resistant horseweed.

146 - Fall Herbicide Applications in Winter Wheat: Does Planting Date Matter?

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Fall postemergence herbicide applications for weed control in winter wheat are gaining interest among Michigan farmers. However, weather conditions and delayed previous crop harvest can extend winter wheat planting 4 to 6 weeks beyond the ideal planting date of mid-September, raising questions about how fall applied herbicides perform across planting dates. Field experiments were conducted at the Michigan State University (MSU) Agronomy Farm in East Lansing, Michigan, (MSU-23, MSU-24, MSU-25), and at the Saginaw Valley Research and Extension Center near Richville, MI, (SVREC-24, SVREC-25) for a total of five site-years. Experiments followed a split-plot randomized complete block design with four replications with the main plot factor as herbicide application timing within planting date and the sub-plot factor as herbicide treatment. Early planted wheat was planted in mid- to late-September and late-planted wheat was planted 4 weeks later. There were two fall herbicide application timings for the early-planted wheat at Feekes stage 1.3 and then approximately two weeks later. For late-planted wheat, the fall application occurred at Feekes 1.2 to 1.3 in early December. Herbicides applied in the fall included: pyrasulfotole + bromoxynil, bicyclopyrone + bromoxynil, thifensulfuron + tribenuron, halauxifen + florasulam, mesosulfuron, and pyroxsulam. Pyrasulfotole + bromoxynil was also tank-mixed with mesosulfuron and pyroxsulam. Fall wheat injury from herbicide applications occurred only at MSU when mesosulfuron and pyroxsulam containing treatments were applied at Feekes stage 1.3 to early planted wheat. Wheat injury from these treatments ranged from 9-11%, 14 d after treatment (DAT), and was characterized by yellowing and stunting. By spring, injury from these treatments were not apparent. At one site-year (MSU-24), wheat injury from treatments containing mesosulfuron and pyroxsulam was 15-18% in mid-April when fall applications were made to later planted wheat. Weed numbers were low at SVREC. Wheat planting date had a significant impact on weed biomass for the different site years at MSU. At MSU-23 & -24, mid-May weed biomass was 3-times greater for early planted compared with later planted wheat in the untreated controls. However, at MSU-25 weed biomass in the later planted wheat was 2-times greater than the early planted wheat. In general, treatments containing halauxifen + florasulam, mesosulfuron + pyrasulfotole + bromoxynil, and pyroxsulam-based treatments provided the greatest weed suppression, with weed biomass levels below 6 g m^{-2} compared with 55.2 g m^{-2} the untreated in the early planted wheat or less than 4 g m^{-2} for these treatment in the later planted wheat compared with 17.8 g m^{-2} for the untreated. Grain yield was influenced by planting date in four of five site-years, but not by herbicide. At MSU-23 and SVREC site years, early planted wheat out yielded the later planting by 1105 and 918 kg ha^{-1}, respectively. At MSU-25, the later planted wheat out yielded the early planting date by 444 kg ha^{-1}. Overall, fall herbicide applications, particularly for early planted wheat, can provide effective weed control without affecting yield, offering a reliable alternative when spring conditions limit application opportunities.

147 - Response of Popcorn and Processing Sweet Corn Hybrids to a Pre-Mix of Saflufenacil and Pyroxasulfone (Surtain®) Applied Pre- and Early Post-Emergence

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Surtain® (pyroxasulfone + encapsulated saflufenacil) is a new herbicide registered for weed control in field corn (*Zea mays* L.). The objective of this study was to evaluate the response of popcorn (*Zea mays* L. var. *everta*) and processing sweet corn (*Zea mays* L. var. *saccharata*) hybrids to Surtain applied preemergence and early postemergence (V3 growth stage) at various rates. Field trials were conducted in 2025 at the University of Nebraska-Lincoln’s South Central Agricultural Laboratory near Clay Center, Nebraska. Four popcorn hybrids (‘Medium White’, ‘Baby Yellow’, ‘Baby White’, and ‘Extra-large Yellow’) and four processing sweet corn hybrids (‘GSS 3951’, ‘Bighorn’, ‘Silver Queen’, and ‘Silver King’) were used in this study to evaluate the response of Surtain applied preemergence and early postemergence. The study was conducted in a split-plot design replicated three times with variety as the main factor and herbicide treatment as the subplot factor. In popcorn, 16 treatments were evaluated: six preemergence treatments including four rates of Surtain and two rates of dimethenamid-P + saflufenacil, and 10 early postemergence treatments including two rates of Surtain, combinations with adjuvants (crop oil concentrate, ammonium sulfate, nonionic surfactant), and topramezone. In processing sweet corn, 16 treatments were evaluated: seven preemergence treatments including five rates of Surtain and two rates of dimethenamid-P + saflufenacil, and nine early postemergence treatments including four rates of Surtain with and without adjuvants. Crop injury (%) was evaluated at 7, 14, and 28 days after preemergence treatments and 7, 14, and 21 days after early postemergence treatments. Crop stand counts were taken 14 days after treatment (DAT) in preemergence applications. Palmer amaranth (*Amaranthus palmeri* S. Watson) density and biomass were collected 5 weeks after preemergence herbicide treatment. No significant injury was observed at any rate of Surtain in either crop. In popcorn, Surtain applied preemergence caused 1.5—3.8% injury at 7 DAT, averaged across hybrids, which declined to <1% by 28 DAT. Acceptable levels (78—100%) of *A. palmeri* control were achieved with preemergence applications, even at lower rates. Surtain applied early postemergence caused 1.3%—4.6% injury 7 DAT, but injury decreased to < 1% by 21 DAT. In sweet corn, Surtain applied preemergence caused 1.6%—2.8% injury 7 DAT, which declined to < 1% by 28 DAT, also high level of *A. palmeri* control was observed which ranged from 82% to 100% in Surtain treatments. Early postemergence treatments caused 0.8—5.0% injury at 7 DAT, but all hybrids fully recovered by 21 DAT.

148 - Use Case for Ultra Precision Targeted Herbicide Applications in Wisconsin Non-GMO Corn and Soybean Cropping Systems

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In Wisconsin, 8-10% of corn and soybean acres are non-GMO and thus have a restricted effective postemergence herbicide portfolio warranting new weed control approaches. Ultra precision targeted herbicide application technology such as the ARA Ecorobotix sprayer with a 6 cm x 6 cm target area allows for high sensitivity of weed detection and precise application of herbicides. This novel technology allows for the approach of a safety zone system where there is no application onto the crop, allowing the possibility of adding non-selective herbicide products to the weed management portfolio along with high foliar herbicide savings potential, revealing a potential fit for the economics and agronomics of the non-GMO row crop market. Thus, the goal of this study was to compare the herbicide savings, weed control, and crop safety capability of an ultra-precision application to a traditional broadcast application to

understand its potential fit. A field study following a 2x3 randomized complete block design was conducted in 2025 at Arlington and Janesville, WI in both corn and soybean for a total of seven different sites. The levels of the first factor were the usage of a standard PRE (standard rates of cloransulam-methyl + sulfentrazone for soybean and saflufenacil + dimethenamid-P + mesotrione for corn) or stronger PRE (higher rates with the addition of pyroxasulfone for soybean and higher rates for corn). Following the PRE application, the levels of the second factor were three different modalities of POST applications: broadcast or targeted application of a selective program (standard rates of fomesafen + bentazon + clethodim for soybean and nicosulfuron + dicamba + diflufenzopyr for corn) or targeted application using a safety zone of a non-selective program (standard rates of fomesafen + glufosinate for soybean and dicamba + diflufenzopyr + glufosinate for corn). Herbicide savings and weed counts were taken at postemergence application while weed mortality and crop injury were taken 14 days after treatment (DAT). Across sites and crops, we reveal that treatments containing a stronger PRE saved significantly more POST herbicide than with a standard PRE when applied using targeted application technology while also having higher weed mortality 14 DAT across all modalities. Both targeted application modalities saved 43-87% POST herbicides while providing similar weed mortality compared to the broadcast application (79-85%) given a stronger PRE was used. Treatments where a standard PRE was used and POST was target applied using the safety zone, the lowest weed mortality (69%) of all treatments occurred due to in-row misses which were remedied by using a stronger PRE. The safety zone modality did not spray the crop (0% crop injury) in all but one corn study. In soybean, the inclusion of fomesafen caused 100% injury incidence when broadcasted which was reduced to 30% when using targeted application. The results of this study identify key parameters influencing the success of targeted herbicide applications, demonstrate proof-of-concept for novel weed control approaches in non-GMO cropping systems, and provide insights that may inform future herbicide labeling decisions and support the continued evolution and adoption of these technologies.

149 - Targeted, Broadcast, or Both? On-Farm Evaluation of Herbicide Application Strategies in Soybean

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New targeted herbicide application technologies, such as the John Deere See & Spray™ may offer the potential to decrease herbicide use by detecting weeds and applying herbicides only on emerged weeds. Using a See & Spray™ Ultimate machine, on-farm field studies were conducted in 2025 near Belleville and Moundridge, Kansas, to compare three application systems: broadcast, targeted spray (single-tank), and targeted plus broadcast (dual-tank), for postemergence weed control and crop response in soybean (*Glycine max L.*). Each application system treatment was assigned to a strip that corresponded with a sprayer pass and replicated three to four times in each field. Within each strip, six 4 x 4 m squares were selected, three with weeds identified and three without weeds. Herbicide programs varied according to farmers' practices. At Belleville, the broadcast treatment applied glufosinate and glyphosate + S-metolachlor, the single-tank system applied both herbicides as a targeted application, and the dual-tank system applied glufosinate as a targeted application while applying glyphosate + S-metolachlor in a

broadcast application. At Moundridge, the broadcast program consisted of glufosinate, dimethenamid-P, glyphosate, and 2,4-D choline; the single-tank targeted application applied all four, and the dual-tank targeted application applied glyphosate, glufosinate, and 2,4-D choline while dimethenamid-P was applied as broadcast. Weed control and soybean injury were visually evaluated 1, 2, and 3 weeks after treatment (WAT). Data were analyzed separately by location using ANOVA and Tukey's HSD. Weed control exceeded 95% for all weeks at both locations. At Belleville, control 1 WAT was greater with the single-tank system, while weed control was similar for all treatments 2 and 3 WAT. No difference was shown for weed control in Moundridge; all systems provided 99% control on all evaluation dates. Soybean injury at Belleville was greater for broadcast and dual-tank treatments compared to single-tank treatments 1 and 2 WAT, but was similar among all treatments 3 WAT. At Moundridge, crop injury was similar for all treatments 1 and 3 WAT, but injury for dual-tank was greater than broadcast and single-tank 2 WAT. Overall, targeted applications resulted in less soybean injury, with reductions of up to 5 percentage points across evaluation dates. These results indicate that targeted herbicide applications can maintain weed control while reducing crop injury in commercial soybean production.

150 - Critical Time for Cereal Rye Termination: Balancing Weed Suppression and Soybean Yield in Planting Green Systems

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Palmer amaranth (*Amaranthus palmeri* S. Watson) and waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] remain the most troublesome weeds to manage in U.S. soybean production systems. Integrating cereal rye cover crop with early soybean planting through the planting green system may improve weed suppression and reduce selection pressure on POST herbicides. This study evaluated how long cereal rye (*Secale cereale* L.) and early planted soybean can coexist following early soybean planting to maximize cereal rye biomass without reducing soybean yield. Field experiments were conducted in 2023 and 2024 using a 7X2 factorial in a randomized complete block design with four replications across 11 U.S. states (AR, IL, IN, KS, KY, MO, MI, ND, NE, OH, and WI). Treatments included seven cereal rye termination times based on soybean growth stage (planting, germination, VE, VC, V1, V2, and V3) and two residual herbicide programs: with and without a residual herbicide at cereal rye termination (pyroxasulfone at 183 g ai ha^{-1}). Cereal rye biomass was recorded at all termination times, *Amaranthus* spp. density were counted at the time of POST application (triggered when either ~20% of *Amaranthus spp.* plants within a treatment reached a height of 10 cm or when soybeans reached the R1 growth stage, whichever occurred first), and stand was recorded when soybean reached physiological maturity. Cereal rye biomass increased with later termination times. Greater cereal rye biomass increased *Amaranthus spp.* suppression compared to lower biomass. Applying a residual herbicide at cereal rye termination further reduced *Amaranthus spp.* density across all termination timings by at least 50%. Soybean yield declined when cereal rye was

terminated after the cotyledon growth stage compared to earlier termination times, and lower yields were associated with lower soybean stand at the end of season. These results indicate that growers do not need to terminate cereal rye before or at planting to protect yield when the soybean is planted early. In fact, early-planted soybean can be successfully established in a planting green system, and terminating cereal rye up to the emergence of the soybean crop in tandem with a residual program provides a balance between maximizing cover crop biomass accumulation, improving *Amaranthus spp.* suppression, and maintaining soybean yield.

151 - What We Learned from Multiyear Wisconsin Research on Glufosinate Tank Mixes and Application Methods

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Glufosinate has become a critical postemergence soybean herbicide for managing herbicide-resistant *Amaranthus* spp. in the United States. Herein we discuss results of a regional stakeholder survey and multi-site tank-mixture efficacy trials and spray-deposition modeling research to identify agronomic, environmental, and physical drivers of glufosinate performance and to support stewardship tactics. According to survey responses, optimal results occur when glufosinate is applied to weeds ≤10 cm under warm (25-30 °C), humid, high-light conditions that favor foliar uptake and glutamine-synthetase inhibition. Since weather cannot be controlled and is often not fully favorable during the application season, the more decisive levers are application timing, nozzle and carrier volume, adjuvant selection, and water quality. Moreover, ammonium sulfate is important in hard-water regions such as Midwest, and routine water testing and hardness mitigation can improve performance. Across Illinois-Wisconsin site-years, glufosinate tank mixtures broadened spectrum and generally improved waterhemp control when applied early; adding Group 14 partners (fomesafen, lactofen) or 2,4-D choline increased efficacy, though lactofen was consistently the most injurious to soybean among tested partners. Spray deposition results explain the importance of application timing. Once soybean canopies exceed 15 cm, interception by upper foliage minimizes nozzle effects, reducing penetration to the deeper levels of soybean canopy, where smaller weeds usually grow. Dose-response modeling of coverage loss quantified a rapid decline beyond 15 cm soybean height, indicating that late applications can face structural barriers regardless of nozzle choice. Canopy interception increases the likelihood of sublethal exposure of under-canopy weeds, imposing selection pressure for resistance to both systemic and contact herbicides; the concurrent reduction in spray coverage further aggravates failure risk for contact herbicides, which are coverage-dependent. Sustaining glufosinate performance will require a multifaceted approach. Priority should be given to well-timed, early-season applications when weeds are no taller than 7.5 cm, and applications that maximize canopy exposure, in tandem with verified water quality and appropriate adjuvants, help preserve deposition and control. Long-term stewardship also depends on strategic tank-mix design, particularly when suboptimal environmental conditions are present for glufosinate. Routine resistance monitoring, mixture and rotation of herbicide sites of action, integration of effective preemergence herbicide programs, and nonchemical options will be important to keep glufosinate a reliable component of diversified soybean weed management across the Midwest.

152 - Integrating Early Spring-planted Barley or Oat with Herbicides for Palmer amaranth Management in Soybean

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Fall-planted cover crops (CCs) are widely used for weed suppression, but CC establishment challenges after fall harvest in temperate regions necessitate alternative approaches. The objectives of this study were to evaluate the integrated effect of spring-planted barley or oat CC and herbicide programs for CC biomass production, Palmer amaranth (*Amaranthus palmeri* S. Watson) suppression, and soybean [*Glycine max* (L.) Merr] yield. Field experiments were conducted during 2023 to 2024 in an irrigated no-till soybean in south central Nebraska. A split-plot design with early spring planted (i) barley (*Hordeum vulgare* L.) CC, (ii) oat (*Avena sativa* L.) CC, and (iii) no cover crop (NCC) as main factors and sub-factors included five herbicide programs: (i) nontreated, (ii) pre-emergence (PRE) only (PRE-only), (iii) post-emergence (POST) only (POST-only) (iv) PRE followed by POST herbicide (PP), (v) PRE followed by POST plus residual herbicide (PPR). Barley or oat were drill-planted a month before soybean planting. Oat produced 42% more biomass than barley in 2023 (1.44 Mg ha^{-1}) and 102% more biomass in 2024 (3.47 Mg ha^{-1}). In 2023, CCs had no effect on Palmer amaranth at CC termination. In 2024, oat and barley without PRE herbicide reduced Palmer amaranth density by 89% and 83% and biomass by 90% and 92%, respectively, compared to NCC without PRE herbicide. At four weeks after POST herbicide application, oat-nontreated treatment reduced Palmer amaranth density by 80% and biomass by 64%, while barley-nontreated had similar results to NCC-nontreated. Soybean yields were not affected by CCs but improved by integrating with herbicide program, with PPR treatment (4.12 Mg ha^{-1}) yielding 225% higher than the nontreated control. It is concluded that spring planted oat CC integrated with herbicides can be included in Palmer amaranth management program in soybean.

153 - Beyond the Boots: A practical Guide to Using Drones for Efficient Herbicide Injury Scouting

Emmanuel G Cooper[1], Maria Carolina CR Souza[1], Leonard B Piveta[1], Bryan G Young[1], Julie M Young[1], Thomas R Butts[1]

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Herbicides are essential for minimizing weed competition and sustaining crop yields but can also cause crop phytotoxicity through tolerance variability or off-target movement, leading to growth inhibition and yield loss. Early detection is critical for identifying causes and assessing season-long impacts, yet traditional scouting is time-consuming and impractical for large-scale operations. Unmanned aerial vehicles (UAVs) equipped with multispectral and red-green-blue (RGB) sensors offer a rapid, non-destructive alternative, but standardized protocols for detecting early herbicide-induced phytotoxicity remain limited. This study evaluated UAV-based assessment of herbicide injury in corn (*Zea Mays* L.) and determined optimal flight parameters for detection. Field experiments were conducted at two locations (Lafayette and West Lafayette, IN) following V3-stage applications of seven herbicides: paraquat (525 g ai ha^{-1}), glufosinate-ammonium (409 g ai ha^{-1}), fomesafen (172 g ai ha^{-1}), imazethapyr (35 g ai ha^{-1}),

cloransulam-methyl (9 g ai ha^{-1}), metribuzin (210 g ai ha^{-1}), and clethodim (26 g ai ha^{-1}). Treatments were arranged in a randomized complete block design with four replications. Visual crop injury, plant height, and UAV imagery (DJI Mavic 3M) at four flight altitudes (22, 31, 61, and 91 m; 1 - 4.2 cm pixel^{-1} resolution) were collected at 3, 7, 14, and 21 days after application (DAA). Data were analyzed using mixed-model ANOVA to test herbicide and flight altitude effects, and Pearson correlations were used to assess relationships among visual injury, plant height, and vegetative indices. Herbicides were grouped as systemic (clethodim, imazethapyr, metribuzin, cloransulam-methyl) or contact (paraquat, glufosinate-ammonium, fomesafen). Crop injury was negatively correlated with plant height for contact (r = -0.88) and systemic (r = -0.72) herbicides at 7 DAA across locations. Herbicide and flight altitude effects were significant, though their interaction was not. Among vegetative indices, the Green Normalized Difference Vegetation Index (GNDVI), Normalized Difference Vegetation Index (NDVI), and Visible Atmospherically Resistant Index (VARI) showed the strongest correlations with visual injury for contact (r ≥ -0.92) and systemic (r ≥ -0.86) herbicides at 7 DAA. Vegetative indices were consistent between 22 and 61 m flight altitudes. Findings suggest that a 61 m flight altitude provides reliable detection of contact herbicide injury at 3 DAA and systemic herbicide injury at 7 DAA using GNDVI, NDVI, and VARI. This approach provides a practical framework for early phytotoxicity monitoring and reduces the need for manual scouting.

154 - Spray Drone Herbicide Options for Late-Season Burcucumber (*Sicyos angulatus*) Management in Corn

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Burcucumber (*Sicyos angulatus* L.) is a problematic summer annual vine with an extended germination period, making season-long control difficult due to herbicide label restrictions. Its vigorous growth further complicates management, as vines climbing the corn (*Zea mays* L.) can cause stalks to break during ground sprayer operations and reduce corn harvestability by binding combine heads. An on-farm experiment was conducted in 2025 at Crawfordsville and Delphi, IN, to evaluate late-season management of burcucumber in corn using a spray drone with applications at two corn growth stages, dent and physiological maturity (black layer). The treatments consisted of a nontreated control, 2,4-D (1,108 ai ha^{-1}), bentazon (1,121 g ai ha^{-1}), nicosulfuron (69 g ai ha^{-1}), and topramezone (49 g ai ha^{-1}) applied at dent and carfentrazone (35 g ai ha^{-1}), glyphosate (841 g ae ha^{-1}), paraquat (546 g ai ha^{-1}), and sodium chlorate (6,724 g ai ha^{-1}) applied at black layer. Treatments were selected based on label requirements for corn desiccation and preharvest intervals. The experiment followed a randomized complete block design with four replications. Applications were made using a DJI Agras T50 spray drone flying 3.7 m above the crop, equipped with dual LX8060SZ rotary atomizer nozzles, calibrated to deliver 28 L ha^{-1} with a Coarse spray and an assumed swath of 9.1 m. Visual burcucumber control and aerial imagery collected from a DJI Mavic 3M drone (used to estimate groundcover) were assessed weekly, and biomass from three burcucumber vines per plot was collected three weeks after the black layer application. All data were analyzed by location using a generalized linear mixed model in R. Two weeks after the black layer application in Crawfordsville, paraquat provided the greatest visual control (87%) followed by

topramezone (65%). All other herbicides provided less than 60% visual control, although nicosulfuron (57%) performed comparably to topramezone. In Delphi, paraquat provided 95% visual control, while all other herbicides were below 60%. Paraquat reduced burcucumber biomass by 82% compared to the nontreated control in Crawfordsville; no biomass differences were observed among treatments in Delphi. Groundcover was reduced only by paraquat and nicosulfuron (77% and 64% reduction compared to the nontreated control) in Crawfordsville; groundcover was not assessed in Delphi. Burcucumber plants in Crawfordsville were larger and a greater number had reached the top of the corn canopy compared to Delphi at application, likely contributing to the observed differences in control and biomass between locations. The findings of this study indicate that paraquat is an effective option for managing late-season burcucumber vegetation in corn, thereby facilitating corn harvest. However, since applications (black layer only) occurred after seed set, earlier-season control remains critical to prevent seedbank replenishment, while late-season herbicides that reduce seed viability may offer additional long-term management benefits.

Student Extension Video Contest

155 - Practical Weed Management for Small Farms

Celia Corado[1], Stephen Meyers[1], Jeanine Arana[1], Nicolle Salamanca[1]

[1]Purdue University

Weed management is one of the most challenging tasks for small-scale farmers, especially when labor, time, and input costs are limited. Underused strategies can help reduce weed pressure while supporting sustainable production. For example, the use of clear plastic tarps to encourage weed emergence followed by opaque silage tarps for occultation, can reduce tillage and herbicide reliance in spring-planted crops such as onion. While flame-weeding and organic herbicides may reduce weed pressure, small farm operators should set realistic expectations for their effectiveness. Hand tools like tine harrows and in-row cultivators, which target small weeds, can reduce hand-weeding demands. Together, these approaches give growers a set of adaptable, low-input options that can be integrated into conventional or organic production systems on small farms. By sharing these tools in a clear and accessible way, small farm operators are empowered to diversify their weed management strategies and improve crop establishment.

156 - Investigating the Influence of Incorporation Depth on Preemergence Weed Control

João Matheus Stempniak Accetti[1, 2], Sarah Lancaster[1], Victoria Johnson[1], Lucas Granzioli[1, 2], Gary Lynn Justesen[3]

[1]Kansas State University, [2]State University of Maringa, [3]UPL NA Corporation Ltd.

Residual herbicides are essential components of weed management. However, the activity of many residual herbicides depends on precipitation for movement into the soil profile. When precipitation is insufficient, mechanical incorporation through tillage may be an alternative to improve herbicide performance. This study aimed to evaluate the influence of herbicide incorporation depth on preemergence weed control. A field experiment was conducted in 2025 at the Ashland Bottoms Research Farm near Manhattan, KS, in a randomized complete block design with four replications. Treatments consisted of two herbicides, each applied at two rates: amicarbazone + metribuzin (0.30 + 0.17 kg a.i ha^{-1} and 0.18 + 0.11 kg a.i ha^{-1}) and amicarbazone + mesotrione (0.19 + 0.10 kg a.i ha^{-1} and 0.30 + 0.15 kg a.i ha^{-1}). Three incorporation depths were evaluated: surface application (0 cm), shallow tillage (5 cm), and deep tillage (10 cm). Herbicides were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 200 L ha^{-1}, equipped with TeeJet TT11002 nozzles. Visible control of *Amaranthus palmeri* S. Watson) and annual grasses was evaluated 28 and 42 days after application (DAA). Data were analyzed using Linear Mixed Models (LMM) in R software (version 4.5.0). The model included herbicide, herbicide rate, and incorporation method as fixed effects and replication as a random effect. Means were separated using Tukey's HSD. At 42 DAA, *A. palmeri* control was similar for both herbicides, but surface application resulted in greater control (69%) compared to shallow (49%) and deep (52%) incorporation. Annual grass control 42 DAA was greater by amicarbazone + mesotrione (42%) than amicarbazone + metribuzin (25%). Furthermore, surface application resulted in greater annual grass control (52%) compared to both the shallow (21%) and deep (26%) incorporation. These data suggest that the herbicides evaluated in this study need to remain concentrated near the soil surface, where the majority of weed seed germination occurs for maximum weed control.

157 - Scouting Italian Ryegrass: When and Where to Look

Abby Connor[1], Disha Ande[1], Travis Legleiter[1]

[1]University of Kentucky

Italian ryegrass (*Lolium perenne L.* spp. *multiflorum*) is a winter annual grass species that has become increasingly troublesome in the southern United States, causing a significant challenge in row crop agriculture. In Kentucky, producers are experiencing increasing difficulty in controlling populations of Italian ryegrass. With an increase in plants emerging in the spring, producers are prioritizing new control strategies. It is important to know the life cycle, emergence patterns, and economic threshold of Italian ryegrass in crop production fields to keep the weed from becoming a yield-limiting problem in a producer's operation. In this video, we will discuss how to accurately identify an Italian ryegrass plant, the best time to scout, where it is commonly found, and the population levels at which control measures should be taken to prevent yield loss. Successfully identifying and controlling populations of Italian ryegrass prior to planting crops such as corn reduced the risk of early-season competition and potential need for a crop replant. Italian ryegrass has similar characteristics to many ryegrass species; it is critical to make a proper identification the first time. In the vegetative stage, Italian ryegrass has clasping auricles that are unique to this species. The most common locations producers will find Italian ryegrass are in winter wheat fields and no-till corn and soybean fields. With spring-emerged and herbicide-resistant Italian ryegrass populations, a spring burndown application will be necessary even following a fall application. Knowing how and when to manage Italian ryegrass will be a major factor in controlling the population and reducing the contributions to the weed seedbank. If farmers implement preventative and integrative weed management strategies, they can greatly reduce Italian ryegrass populations and maintain yield goals for corn, soybeans, and wheat.

158 - Volunteer Wheat Management to Reduce Wheat Streak Mosaic Virus

Lucas Granzioli[1, 2], Sarah Lancaster[2], Victoria Johnson[2], Joao Matheus Accetti[1, 2], Kelsey Anderson Onofre[2]

[1]State University of Maringa, Brazil, [2]Department of Agronomy, Kansas State University

Volunteer wheat plays a key role in the epidemiology of Wheat Streak Mosaic Virus (WSMV), serving as a "green bridge" for wheat curl mites during the summer. These mites survive primarily on volunteer wheat plants that emerge after harvest due to grain losses from wind, hail, lodging, or combine settings. If uncontrolled, volunteer wheat allows mites and viruses to survive between wheat crops, leading to early infection and reduced yield in the subsequent wheat crop. Recent extension recommendations emphasize maintaining a 30-day "wheat-free window" before the optimal planting date of winter wheat, replacing the older two-week guideline. Effective management requires complete elimination of volunteer wheat and other cereal hosts, such as rye or triticale, to disrupt the green bridge and prevent mite migration. Field trials were conducted at Kansas State University to evaluate herbicides for volunteer wheat control. The experimental design was a randomized complete block with four replications, and the plots measured 3 x 9.1 m. All herbicide applications were made to 10-cm-tall volunteer wheat using a CO_2^- pressurized backpack sprayer equipped with a four-nozzle boom fitted with AIXR-110 flat-fan nozzles, calibrated to deliver a spray volume of 140 L ha^{-1}. Treatments included atrazine (1.12 kg a.i ha^{-1}), metribuzin (0.63 kg a.i ha^{-1}), sulfentrazone (1.12 kg a.i ha^{-1}), saflufenacil (0.05 kg a.i ha^{-1}), tiafenacil (0.05 kg a.i ha^{-1}), epyrifenacil (0.05 kg a.i ha^{-1}), carfentrazone (0.018 kg a.i ha^{-1}) and metribuzin + amicarbazone (0.17 kg a.i ha^{-1} + 0.30 kg a.i ha^{-1}). All these treatments were applied in a mixture with glyphosate. Paraquat alone (0.84 kg a.i ha^{-1}) and glyphosate alone (1.26 kg a.i ha^{-1}) were included as standard treatments. Appropriate adjuvants were included when required for herbicide performance according to label recommendations. Herbicide treatments differed in volunteer wheat control over time ($p < 0.001$). Paraquat provided rapid burndown, exceeding 90% control within four days after (4 DAT) treatment. Treatments containing metribuzin, sulfentrazone, and other residual herbicides exhibited slower initial activity but maintained excellent control (90-98%) by 45 DAT. Atrazine and amicarbazone + metribuzin also provided excellent control 45 DAT, despite lower early performance. Overall, integrating glyphosate with residual herbicides provided the most effective control strategy to eliminate the green bridge and reduce Wheat Streak Mosaic Virus transmission risk in Kansas wheat production systems.

159 - The Life of Ryegrass: Why Timing Matters

Disha Ande[1], Abby Connor[1], Travis Legleiter[1]

[1]University of Kentucky

Italian ryegrass (*Lolium perenne ssp. multiflorum*) is a major and persistent weed problem in Kentucky's winter wheat, corn, and soybean production systems. Once regarded primarily as a winter annual, it has adapted to emerge in both fall and spring. This shift in emergence pattern has made the weed increasingly difficult to predict and control. Effective management begins with understanding when ryegrass emerges as control success depends heavily on the timing of each management step.

This video explains how the life cycle and emergence pattern of Italian ryegrass influence control effectiveness. Ryegrass typically germinates and establishes in the fall, surviving through winter and resuming active growth early in the spring. In many fields, multiple flushes of emergence occur across seasons, resulting in plants of various sizes by the time spring burndown is applied. When herbicide applications are delayed until ryegrass is larger or tillered, control often drops sharply, and those surviving plants replenish the seedbank for future seasons.

The discussion emphasizes how early detection and proper timing of control practices can reduce infestations and limit seed production. Farmers are encouraged to scout fields frequently in late fall and early spring, identify small seedlings before they tiller, and apply herbicides when plants are still at their most susceptible growth stage. Observing these timing principles ensures that ryegrass populations are managed before they compete with crops or contribute to the seedbank.

Understanding the lifecycle of Italian ryegrass is essential for developing practical, long-term control strategies. Timely scouting, early intervention, and integrating management approaches allow producers to keep ryegrass populations manageable and prevent further spread across Kentucky fields. Recognizing that the correct timing, and not just the correct herbicide is a critical factor in controlling this weed. Maintaining proper timing in control practices will strengthen weed management programs and help protect yield potential in Kentucky grain production systems.

160 - Planting Green: Corn in Cereal Rye

Ankit Yadav[1], Vipin Kumar[1], Amit Jhala[1]

[1]University of Nebraska-Lincoln

Planting-green (PG) is a management approach where the main crop is planted directly into a living cover crop (CC) stand, with the CC terminated at or some days after main crop planting. PG practices can enhance CC biomass production and weed suppression, though they may also negatively impact main crop yield. This experiment, conducted at the South-Central Agricultural Lab in Harvard, NE, evaluated various cereal rye (Secale cereale L.) CC termination timings within a PG framework and different herbicide programs to assess CC biomass accumulation, weed suppression, and corn yield. Nitrogen dose was split into two parts with 80% applied before planting and 20% at the V3 growth stage. The experiment followed a split-plot design with four replications. The main plot factor included cereal rye termination at different corn (Zea mays L.) growth stages: at planting, at emergence, V1, V2, and V3, along with a no cover crop (NCC) control. The sub-plot factor comprised four herbicide programs: nontreated, pre-emergence (PRE) only, post-emergence (POST) only, and PRE followed by POST. Cereal rye biomass increased with delayed termination, with the V3 termination yielding the highest biomass (9,675 lb ac $^{-1}$) and termination at planting yielding the lowest (5,100 lb ac^{-1}). Across herbicide treatments, termination at planting and at emergence resulted in 93% Palmer amaranth (*Amaranthus palmeri* S. Watson) control compared to NCC at the POST herbicide application. Terminations at V1, V2, and V3 provided more than 97% Palmer amaranth control compared to NCC. At 28 days after POST herbicide application, at planting, and at emergence, provided 75% Palmer amaranth control, and V1, V2, and V3 termination had 90% control compared to NCC. By corn harvest, Palmer amaranth control in the planting and emergence plots was 65%, while V1, V2, and V3 terminations achieved 80% control. Similar trends were observed in Palmer amaranth biomass at corn harvest, with reductions of 55% at

planting and 77% at emergence termination, and more than 95% reductions with V1, V2, and V3 terminations compared to NCC. Corn yield was lowest in the untreated NCC plots (116 bushel ac^{-1}), followed by POST-treated NCC plots (182 bushel ac^{-1}). In all other treatment combinations, corn yield varied between 221-249 bushel ac^{-1}, but this difference was not statistically significant at 5% level of significance. Overall, these results indicate that delaying CC termination can enhance biomass production and improve Palmer amaranth control without adversely affecting corn yield.

161 - Targeted Spraying Technologies: How They Work and Why They Matter

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[1]University of Wisconsin-Madison, [2]Bosch BASF Smart Farming - One Smart Spray

Targeted herbicide application technologies represent a promising approach to reducing foliar herbicide use while maintaining effective weed control. This field equipment demonstration video highlights the capabilities of targeted spraying systems using the One Smart Spray small-plot research unit as a case study, illustrating how these technologies can detect and treat weeds with precision. In the video we illustrate key technological features common to advanced targeted application platforms such as real-time weed detection and single vs multiple nozzle activation allowing for detailed evaluation of spray coverage, herbicide savings, and weed control performance under various field conditions. The One Smart Spray system employs an array of cameras and lighting units spaced 1 m apart along the boom. Each camera integrates RGB with infrared and near-infrared filters and is driven by an artificial intelligence algorithm capable of detecting weeds as small as 0.5 cm under varying light conditions. The system supports four operational modes: (1) traditional broadcast; (2) green-on-brown detection for burndown applications; (3) green-on-green detection for in-crop spraying; and (4) dual-tank dual-boom functionality that allows simultaneous broadcast and targeted applications (e.g., broadcast residual and targeted foliar herbicides). An additional feature in the One Smart Spray system is the single- versus three-nozzle activation upon weed detection, which can influence spray coverage and herbicide savings depending on weed density and spatial distribution. Previous work conducted by our Wisconsin Cropping Systems Weed Science lab using a custom-built sprayer designed to simulate targeted applications demonstrated that activating multiple nozzles upon weed detection increased spray coverage (43%), weed control (>92%), and biomass reduction (95%) compared to single-nozzle activation, which achieved 23% spray coverage, 78% weed control, and 87% biomass reduction. Spray coverage was evaluated under both field and controlled environment conditions, where multiple-nozzle activation at the ideal boom height of 53 cm and presence of wind, consistently provided the greatest coverage compared to 76 cm boom height. These findings highlight the value of multiple-nozzle activation, particularly under windy conditions. Additional research is needed to evaluate how nozzle selection, system sensitivity settings, and other operational factors influence performance under a broader range of environmental conditions.

162 - Tank-Mix Failures: How to Avoid Common Mistakes

Grant D. Isaacs[1], Abigail N. Norsworthy[1], Bryan G. Young[1]

[1]Purdue University

Herbicides play a crucial role in weed management, often combined with multiple herbicide products in tank mixtures to enhance herbicide efficacy and optimize operational efficiency by minimizing field passes. Despite these benefits, improper tank-mixing procedures such as inadequate carrier volume, incorrect mixing order, and failure to adhere to herbicide labels can result in physical or chemical incompatibilities that compromise efficacy. Problems may include clogged nozzles, uneven deposition, or ultimately, reduced weed control. The objective of this video is to highlight common challenges encountered when mixing multiple herbicides in a tank and to provide practical strategies to avoid costly errors. Understanding the correct procedures, from sufficient carrier volume before mixing to following proper mixing order, can optimize herbicide performance and prevent potential setbacks in agricultural operations. By promoting best practices, this video aims to promote greater efficiency, sustainability, and effectiveness in herbicide application strategies.

163 - Managing Strawberry Runners with Napropamide

Jeanine Arana[1], Stephen Meyers[1], Celia Corado[1], Nicolle Salamanca[1], Helen Nocito[1]

[1]Purdue University

Plasticulture strawberry (*Fragaria × ananassa Duch.*) growers face labor challenges when removing runners, especially after daughter plants root into the aisles. Rooted daughter plants divert resources from the mother plant, complicating maintenance and harvest in multiyear plasticulture systems. Napropamide, a preemergence herbicide used in plasticulture strawberries, can be applied under mulch and between rows pre-transplant, and between rows only post-transplant. Its root-inhibiting activity may also limit daughter plant rooting and simplify removal. A greenhouse experiment was conducted using a three-pot system in which the center pot contained a strawberry mother plant with two runners, each with one daughter plant, which were placed in the side pots. Napropamide was applied at 4.5 kg a.i. ha^{-1} under four simulated field placement scenarios: (1) nontreated control, (2) broadcast application (mother plants, runners, and side pots sprayed), (3) in-row application (mother and runners only), and (4) between-row application (side pots only). Data were collected at 4 and 8 weeks after treatment (WAT). At 4 WAT, plant injury was visually evaluated on the mother plants. One runner and its attached daughter plant growing in a side-pot were destructively sampled to measure rooting pull force, runner length (from the daughter plant to the growing point of its runner), and the number of newly formed daughter plants emerging from that runner. At 8 WAT, mother plants were again rated for injury and then harvested to determine their biomass. The second runner and attached daughter plant from the opposite side-pot were destructively sampled, and the same measurements (rooting pull force, runner length, and number of newly formed daughter plants) were recorded. At both data collection timings, mother plant injury did not exceed 20%, and biomass was unaffected. At 4 WAT, rooting resistance was observed only in daughter plants of the nontreated control, which required an average pull force of 1 kg to detach from the soil. In contrast, daughter plants from all napropamide treatments detached easily, indicating minimal or no root development. Runner length decreased from 72 cm in the nontreated control to 57, 31, and 29 cm in the between-row, broadcast, and in-row treatments, respectively. The number of new daughter plants per runner decreased from 2.6 in the control to 2.3, 1.4, and 1.3 in the between-row, broadcast, and in-row treatments, respectively. At 8 weeks, the in-row and between-row treatments were less effective, with pull-force values statistically similar to both the nontreated control (5.2 kg) and the broadcast treatment

(0.9 kg), whereas the broadcast application remained significantly lower than the control. Runner length and new daughter plants count followed the same trend, with runner length decreasing from 127 cm in the control to 40 cm in the broadcast treatment, and new daughter plants number per runner decreasing from 4.3 in the control to 1.9 in the broadcast treatment. Napropamide effectively delayed rooting and reduced runner development. While broadcast applications are not labeled, between-row applications, which are already permitted for weed control, show potential to ease runner removal and reduce labor needs.

Symposium – Use & Role of Biological Based Products in Agricultural Practices

164 - How did we get here and where are we headed? A review of biological pest control agents in the market and a look to the future

Pam Marrone[1]

[1]Invasive Species Corporation

Keynote Address. *Abstract not available.*

165 - Biopesticides in Use Today and Into the Future

Jonathan Huff[1]

[1]Corteva AgriScience

Abstract not available.

166 - Bio-efficacy Enhancers Used Today and Into the Future

Adam Monroe[1]

[1]Zymtronix

Abstract not available.

167 - Bio-based Adjuvants in Use Today and Into the Future

Matthew Faletti[1]

[1]Precision Laboratories, Inc.

Abstract not available.

168 - Biologicals Panel Discussion Q&A

Pamela Marrone[1], Adam Monroe[2], Jonathan Huff[3], Matthew Faletti[4]

[1]Invasive Species Corporation, [2]Zymtronix, [3]Corteva AgriScience, [4]Precision Laboratories, LLC

This Symposium seeks to provide an understanding of the expanding use of bio-based products in agricultural practices. Through a review of the development of biopesticides, biorationals and bio-adjuvants the symposium will provide a historical perspective of the field as well as a futuristic look toward the integration and use of bio-based products in the field.

Rangeland, Pasture & Vegetative Weed Management

169 - Does surfactant type influence herbicide control of wintercreeper (*Euonymus fortunei*)

George Oganda[1], Dr. Reid Smeda[1]

[1]University of Missouri

Wintercreeper (*Euonymus fortunei* (Turcz.) Hand.-Maz.), originally introduced to the United States as an ornamental ground cover, has escaped cultivation and is now recognized as an invasive species or a serious ecological threat in many states east of, or bordering, the Mississippi River. Plants are characterized as having thick, waxy cuticles on leaf surfaces, which poses a challenge for effective control with herbicides. Delivery of a lethal dose of herbicide is critical because these plants spread by stolons and have an extensive root system. A greenhouse study conducted at the University of Missouri-Columbia was established to compare the efficacy of foliar applications of different surfactants with either triclopyr or aminopyralid on established wintercreeper. Seedlings were established in 20 cm pots for a period of eight months. Aminopyralid (0.12 kg ai ha^{-1}) or triclopyr (0.96 kg ai ha^{-1}) were applied in a spray volume of 140 L ha^{-1} with one of the following surfactants: nonionic surfactant (NIS; 0.3% v/v), AU 972 (fatty acid complex alkoxylates + ethoxylated soybean oil; 1% v/v), AU 812 (MSO; 0.4% v/v), AU 6994 (NIS, penetrating oil, citric acid + oligomeric resin; 1% v/v), or crop oil concentrate (COC; 1% v/v). In the absence of any surfactant, visual injury of triclopyr and aminopyralid at 21 days after treatment (DAT) were less than 50% and plants exhibited new growth. Addition of AU 812 improved activity of triclopyr (+20%) versus no surfactant but had little influence on aminopyralid activity (+8%). Addition of AU 972 improved wintercreeper injury by 18-19% for both herbicides. However, addition of AU 6994 increased visual injury for both herbicides by 34-35%, and plants treated with either herbicide or AU 6994 exhibited greater than 90% injury by 21 DAT. The use of complex surfactants may be necessary to optimize both retention and penetration of herbicides for effective wintercreeper control.

170 - Effect of 2,4-D followed by wiper-applied glyphosate on leafy spurge (*Euphorbia esula*)

Eric Jones[1], Jill Alms[1], David Vos[1]

[1]South Dakota State University

Outdoor studies were conducted to determine the extent of leafy spurge biomass reduction resulting from broadcast application of 2,4-D (2,244 g ae ha^{-1}) with and without wiper-applied glyphosate. Glyphosate (575 g ae L^{-1}) was applied at 0%, 33%, 50%, and 75% diluted concentrate with a wiper 24 h after 2,4-D was broadcast-applied. Injury estimates and shoot biomass did not differ between plants treated with 2,4-D only or when glyphosate was wiper-applied 21 d after treatment. Shoot regrowth biomass of plants treated with 2,4-D only was approximately 560% greater than nontreated plants 3 mo after treatment. Plants treated with wiper-applied glyphosate exhibited shoot regrowth biomass of less than 10% compared with nontreated plants 3 mo after treatment. Root biomass of plants treated with 2,4-D only (160% of nontreated plants) exhibited a similar pattern of shoot regrowth biomass. Root biomass of plants treated with wiper-applied glyphosate exhibited approximately 50% reductions compared with nontreated plants. All vegetative metrics were equally reduced with all tested concentrations of glyphosate; therefore, all labeled concentrations should be effective. The results of the experiment indicate that broadcast-applied 2,4-D is more effective at reducing leafy spurge biomass with the addition of wiper-applied glyphosate.

Extension Section

171 - Identifying and mitigating the concerns around the ESA Herbicide Strategy in Iowa

Wesley Everman[1], Ruoyu Wang[1], Katie Dentzman[1], David Hennessy[1]

[1]Iowa State University

The EPA herbicide strategy is an important development in the weed science realm, with far reaching implications and changes to the industry. There is not a clear understanding of what the short and long term impacts will be for industry groups or farmers. A series of roundtables and surveys were conducted in Iowa in 2025 to assess the concerns and impacts for retailers and growers.

Participants were asked questions to gauge their awareness on the herbicide strategy. Initial results indicate that most retailers are aware of the herbicide strategy, while growers were only about 50% aware, with flexibility as a top concern for both groups. Retailers were also concerned about the impact on their workforce and integrating the changes. Growers were more concerned about impacts on profitability. In response to concerns and identified needs, several tools and resources have been developed to educate growers and reduce stress associated with adoption.

172 - Corn and Soybean Herbicide Performance on Common Ragweed Resistant to Groups 2, 9, and 14 Herbicides

Joseph Ikley[1], Austin Weippert[1]

[1]NDSU

Common ragweed (*Ambrosia artemisiifolia* L.) is becoming more problematic within the Red River Valley of North Dakota and Minnesota. Populations have become resistance to herbicide sites of action 2, 9, and 14, with some populations being investigated for resistance to Group 4 herbicides. Many farmers in the region have a diverse crop rotation that places further restrictions on available herbicides due to tight crop rotation intervals. With limited new chemistry that is effective on common ragweed, all commercial options should be explored on these populations. Three different experiments were conducted in 2025 on a common ragweed population near Wolverton, MN that is resistant to Groups 2, 9, and 14. All experiments were a RCBD with four replications. The field was conventionally tilled prior to trial initiation. A preemergence soybean trial evaluated 11 different herbicide treatments across Groups 2, 5, 13, and 14. Treatments were applied the day of planting, and plots were visibly evaluated for crop injury and weed control at 28, 42, and 56 days after planting (DAP). A postemergence soybean trial evaluated 9 different herbicide treatments across Groups 2, 4, 9, 10, and 14. Treatments were applied on 7.5 cm tall common ragweed plants, and crop safety and weed control were evaluated 7, 14, and 28 days after treatment (DAT). Yield was collected from both trials at soybean maturity. A bareground trial was initiated containing 4 preemergence and 5 postemergence corn herbicides at similar timings to the soybean trials. The herbicides covered Groups 4, 5, 14, and 27. Treatments were evaluated at similar timings to the soybean trials. For the soybean preemergence trial, metribuzin applied at 560 g and 840 g ai ha^{-1} and clomazone at 840 g ai ha^{-1} were the only treatments with greater control and greater yield than the non-treated check. For the postemergence soybean trial, glyphosate at 1260 g ae ha^{-1}, glufosinate-P at 338 g ae ha^{-1}, and 2,4-D at 1064 g ae ha^{-1} were the only treatments with greater control and greater yield than the non-treated check. For the preemergence treatments in the bareground trial, common ragweed control ranked as follows: isoxaflutole at 96 g ai ha^{-1} > bicyclopyrone at 50 g ai ha^{-1} > atrazine at 1120 g ai ha^{-1} > saflufenacil at 75 g ai ha^{-1} = non-treated check. For the postemergence treatments in the bareground trial, common ragweed control ranked as follows: topramezone at 24.5 g ai ha^{-1} > tolpyralate at 29 g ai ha^{-1} > clopyralid at 105 g ae ha^{-1} > atrazine at 560 g ai ha^{-1} = non-treated check. These results indicate that metribuzin and clomazone are viable preemergence options in soybean, but their use may be limited due to crop rotation restrictions. Postemergence options in soybean were limited to soybean varieties with herbicide-resistance traits. The herbicides that provided the greatest control in corn also have some rotational restriction considerations. Future research will evaluate tank-mix combinations applied at reduced rates to achieve acceptable common ragweed control with more favorable crop rotation intervals.

173 - Pyridate as a PSII Alternative for Corn Weed Management Systems

Grant D. Isaacs[1], Thomas R. Butts[1], Bryan G. Young[1]

[1]Purdue University

The photosystem II (PSII) inhibitor atrazine (HRAC Group 5) has been a cornerstone of corn (*Zea mays* L.) weed management since its introduction in the 1950s. Atrazine binds to Serine 264 on the D1 protein of the PSII complex, thereby disrupting electron transport and inhibiting photosynthesis in susceptible species. Atrazine remains one of the most widely used herbicides in corn production systems due to the wide spectrum of broadleaf weeds control and the relatively low cost for the herbicide. The combination of atrazine with 4-hydroxyphenylpyruvate dioxygenase inhibitors (HRAC Group 27), such as mesotrione or tembotrione, exhibits synergistic interactions that improves postemergence control of both monocot and dicot weeds. However, increasing regulatory pressure and the prevalence of weeds such as waterhemp with resistance to atrazine forces an analysis of herbicide options to maintain robust weed management. Pyridate (HRAC Group 6) is a PSII-inhibitor that binds to Histidine 215 on the D1 protein and was first commercialized in the 1970s, but has recently received greater market focus to address the aforementioned weed management challenges. However, limited research has evaluated the compatibility and potential synergy of pyridate with HPPD-inhibitors for postemergence weed control in corn. Field research was conducted to evaluate pyridate applied postemergence alone and in combination with mesotrione or tembotrione for control of waterhemp (*Amaranthus tuberculatus* [Moq.] J.D. Sauer) and Palmer amaranth (*Amaranthus palmeri* S. Watson). By 28 days after treatment, pyridate applied alone resulted in less than 21% biomass reduction in waterhemp and Palmer amaranth. In contrast, biomass was reduced by more than 87% with pyridate combinations of mesotrione or tembotrione. Furthermore, the tank mixture of pyridate with mesotrione or tembotrione yielded synergistic activity and substantial control of *Amaranthus* species. Thus, the foliar activity of pyridate can produce synergistic weed control when combined with HPPD-inhibitors, similar to the interactions documented for atrazine. However, the lack of soil residual activity of pyridate compared to atrazine may be another consideration for overall use for postemergence weed control in corn.

174 - From Combines to Cover Crops: Statewide Extension Efforts to Promote Integrated Weed Management in Wisconsin

Daniel Smith[1], Ryan DeWerff[1], Amadreza Mobli[1], Rodrigo Werle[1]

[1]University of Wisconsin-Madison

Ten years ago, waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer) was not a widespread management challenge for Wisconsin corn and soybean farmers. Although waterhemp is native to Wisconsin, farmers were having success with controlling this troublesome weed with herbicides and crop rotations. During this same time, Wisconsin farmers were faced with more cases of herbicide resistance in waterhemp populations. Over the past ten years, Wisconsin farms have seen a dramatic decrease in forage-based crop rotations as dairy farms close, leading to fewer weed management practices being available to farmers and replacing the forage crop rotations with corn and soybean crop rotations. Since 2018, many training workshops and outreach presentations have included combine cleaning for weed seed management. Weed seed movement was a constant theme in many cases where farmers were seeing a new infestation of waterhemp. A 2020 study the research team asked farmers from across Wisconsin to send in crop residue contained in multiple locations on and inside a combine to determine that farmers should focus on cleaning the combine head, feeder house, and rock trap during the in-field combine cleaning. These practices are showcased during Wisconsin combine cleaning clinics. Since 2018, there have been twenty combine cleaning clinics and only two new combines did not contain weed seed. Starting in spring of 2018, University of Wisconsin-Madison researchers began evaluating herbicide options for waterhemp control. This work started with the waterhemp challenge studies, these studies provided small plot evaluation of the common preemergence herbicide options for soybean. These studies were necessary as producers were not commonly using soybean preemergence herbicides. These studies provided foundational data for recommendations for controlling waterhemp in soybean, work that continues to be built upon today. During one of the field tours of these studies, an extension educator observed that tillage was the foundation for our herbicide-based program and challenged the team to explore weed suppression options beyond herbicides and tillage. That fall the systems-based weed control studies were established at the Lancaster and Arlington Agricultural Research Stations in Southern Wisconsin. This study compares the effects of tillage and cover crop termination timing in a corn and soybean systems-based study in combination with preemergence herbicides. These studies were the beginning of the team's work on using cereal rye (*Secale cereale*) biomass to suppress waterhemp in corn and soybean cropping systems. These studies have shown there are limited drawbacks to using cereal rye prior to soybean. Following extensive data collection from multiple studies, best management recommendations were developed, and an outreach strategy was needed. Starting in 2024, a team of Extension educators developed the fall weed management workshop to provide education on an aspect of weed control, feature the newest technology in weed control like targeted spray application and laser weeding equipment, and connect with stakeholders early in the planning process for next year's weed control program. University of Wisconsin research and outreach has helped provide practical insights into waterhemp management for Wisconsin and North Central region farmers.

Symposium – What's New in Extension

175 - Data Dumps and Decision Support: Applying AI (Augmented Intelligence) in Extension

J. Mark Locklear[1]

[1]Extension Foundation

Generative artificial intelligence (AI) is rapidly changing how professionals in every field discover, synthesize, and apply information. In agriculture, these technologies offer the potential to bridge the gap between research outputs and the day-to-day decisions of growers, educators, and industry stakeholders. Tools like large language models (LLMs) can summarize complex technical publications, provide conversational access to knowledge, and integrate diverse resources into a single, user-friendly interface. For Extension, this opens new possibilities for delivering timely, research-based recommendations for its constituents.

At the same time, AI introduces challenges around data quality, accuracy, and transparency. Unlike search engines, generative models must be guided by well-structured, authoritative content if they are to deliver trustworthy results. To illustrate these opportunities and challenges, this presentation will highlight ExtensionBot, an AI-powered chatbot developed by the Extension Foundation. ExtensionBot uses retrieval-augmented generation (RAG) to connect land-grant university publications and decision-support tools to end users through conversational AI. Supporting this system are MERLIN, a platform for managing validated Extension datasets, and Archimedes, a dedicated server for developing and running web crawlers that standardize content into machine-readable formats. Together, these components ensure that AI-generated responses remain grounded in credible, science-based information.

Beyond chatbots, we will also explore the broader AI landscape in agriculture, from predictive analytics for pest and disease outbreaks to computer vision for weed identification. This session will provide a forward-looking perspective on how embracing these technologies can enhance the reach, efficiency, and impact of Extension services, ensuring we remain relevant in the 21st century.

176 - Name that in a snap with an app: A review of plant identification technologies

Erin Hill[1]

[1]Michigan State University

Accurate and timely plant identification is the foundation of developing and implementing weed control programs, whether this is at the commercial scale or in your own backyard. Historically, this skill has been learned in the classroom or on the job, requiring repeated encounters to be committed to memory. Today, however, smartphone applications and artificial intelligence are providing instant answers in the palm of our hands. Can we trust those answers? Students in Michigan State University's Weed Science Lab (CSS226L) have been evaluating these technologies for the past 8 years. This includes 17 smartphone apps, and in 2025, we added three artificial intelligence platforms. The plant categories investigated thus far include ornamentals, vegetative and flowering broadleaf weeds, vegetative and flowering grassy weeds, seedlings (Amaranthus, grass, and winter annual), and deciduous and evergreen trees and shrubs. This session will discuss the strengths and weaknesses of these technologies and the changes we have seen over time. As planned, the information gained from this activity has been helpful to students entering careers in agronomic, horticultural, and turfgrass-related industries. It has also been a surprisingly hot topic among commodity groups and other extension-related organizations across the region.

177 - The Extension Connection: How Farmers and Ag Professionals Really Want to Receive Information

David Nicolai[1], Seth Naeve[1], Kristina Cibuzar[1]

[1]University of Minnesota, St. Paul, MN

Extension Educators and State Extension Specialists have delivered educational and technical information to crop producers and ag professionals utilizing a wide variety of methods for several decades. While some methods may have been more effective in knowledge gain and behavioral changes others may have not been as effective. To better understand how current Minnesota farmers and ag professionals desire to receive crop production information for crop management decisions the Minnesota Soybean Producer Needs Assessment was developed and conducted by the University of Minnesota (UMN) Extension, in partnership with the Minnesota Soybean Research and Promotion Council (MSR&PC). The survey was distributed online via the electronic University of Minnesota newsletter "Minnesota Crop News" from April through October 2025 and aimed to identify key information sources, barriers to educational engagement, and opportunities to improve Extension programming and communication strategies across the state's soybean sector. A total of 105 responses were received, comprising 54 soybean producers and 51 agricultural professionals representing more than 30 Minnesota counties. Respondents provided information on internet access, preferred learning methods, and Extension engagement. Most participants reported reliable broadband access (89%) and frequent use of smartphones and laptops (over 85%) for professional purposes. Both producers and professionals reported moderate engagement with artificial intelligence (AI)-generated agronomic content, though only a small percentage indicated regular use for sourcing original research information. Findings revealed strong interest in digital delivery formats, with the majority of respondents preferring online materials, webinars, and digital newsletters as their primary means of accessing soybean research. However, 65% of producers still preferred in-person events as a source of information if available compared to 38% of ag professionals. The winter season (December-February) was identified as the preferred time to engage with educational content, reflecting the slower pace of field operations. Participants overwhelmingly favored short-format learning opportunities (two hours or less) or half-day workshops, emphasizing flexibility and time efficiency. While in-person programming remained valued for its networking and peer-to-peer learning opportunities, online formats were preferred for their convenience, cost-effectiveness, and accessibility. Trust in UMN Extension as a credible source of research-based information was consistently high. Among agricultural professionals, 79% indicated that they value Extension for its research foundation, and 70% cited trust in Extension resources as a major factor influencing their engagement. Similarly, 75% of soybean producers valued Extension’s unbiased and science-driven approach, while 69% emphasized their trust in the information provided. The most commonly cited Extension resources included Minnesota Crop News, Let’s Talk Crops webinars, and nutrient management podcasts. The most frequently mentioned barriers to participating in educational events were scheduling conflicts, time constraints, and limited awareness of available programs. Distance and cost were rarely cited by producers to influence participation, except if the drive time to an in-person programs exceeded eighty miles. The survey findings illustrated that a dynamic information environment in which producers integrate multiple trusted sources for agronomic decision-making was desirable.

Row Crop Herbicides

178 - Capturing Stakeholder Perspectives in Weed Science: Implications for Extension Programming and Graduate Training

Rodrigo Werle[1], Guilherme Chudzik[1], Zaim Ugljic[1], Nikola Arsenijevic[1]

[1]University of Wisconsin - Madison

Understanding stakeholder perspectives is essential for developing relevant and impactful Extension programming in weed science. Surveys provide a practical and data-driven approach to identify current weed management challenges, document on-farm practices, and evaluate the effectiveness and reach of Extension activities. This presentation will highlight how survey-based research has been used to inform the University of Wisconsin-Madison Cropping Systems Weed Science Extension Program (aka WiscWeeds) and to train graduate students in applied research and stakeholder engagement. For instance, our surveys have documented growers’ and crop consultants’ experiences with cover crops, herbicide programs, and novel spray technologies across Wisconsin and the U.S. Midwest. These efforts have revealed key management trends and guided future research and outreach priorities. For example, a

statewide survey assessing cover crop adoption and impact on weed management in corn-soybean systems identified waterhemp (*Amaranthus tuberculatus*) and giant ragweed (*Ambrosia trifida*) as the most troublesome weeds. Over 90% of respondents reported using herbicides for cover crop termination, and 68% agreed that cover crops, primarily cereal rye (*Secale cereale*), improved overall weed control to some extent. These insights have reinforced the value of integrating cover crops into weed management programs and provided a quantitative benchmark for future evaluations. Another survey focusing on glufosinate use in soybean production across Wisconsin assessed stakeholder perceptions of efficacy, application practices, and environmental factors influencing performance. Responses indicated that targeting small weeds (<10 cm) under warm, humid, high-light conditions optimized control. Ammonium sulfate was recognized as a key adjuvant for improving glufosinate activity in hard-water regions. While glufosinate remains a reliable postemergence partner for managing waterhemp and giant ragweed in Wisconsin, sustained performance will depend on diverse programs incorporating multiple sites of action and nonchemical tactics. A third survey evaluated stakeholder perceptions of targeted spraying technologies in Midwest corn-soybean systems. While many participants recognized the potential of targeted spraying to improve herbicide efficiency, adoption uncertainty remains high due to limited information and familiarity. These findings emphasize the need for continued Extension efforts to demonstrate the utility and reliability of precision spray technologies. Survey-based approaches have also been integrated into our WiscWeeds herbicide resistance monitoring program. Instead of traveling across the state to collect weed seed samples, we ask stakeholders to collect seeds from populations of concern and submit them to the university for testing. Along with the samples, participants provide field history and herbicide application records, enabling us to better understand management practices contributing to resistance evolution. This participatory model has increased stakeholder engagement, broadened geographic sample coverage, and strengthened Extension's ability to deliver relevant resistance management recommendations. Collectively, these survey efforts have enhanced our understanding of current weed management challenges, documented Extension impact, and strengthened the connection between research and stakeholder needs. For graduate students, survey design and implementation provided valuable experience in communication, data management, and stakeholder collaboration, skills critical for future Extension and Industry professionals.

179 - Sonic Boom: A New Corteva Soybean PRE Herbicide

Spencer Samuelson[1], Kelly Backscheider[1], Lowell Sandell[1], Kristin Rosenbaum[1], Claudio Vrisman[1]

[1]Corteva Agriscience

Sonic Boom® is a liquid SC premix herbicide with a 2:1 ratio of metribuzin (Group 5) and sulfentrazone (Group 14), respectively, from Corteva Agriscience™. Sonic Boom is labeled for preemergence application in soybean and provides residual weed control of small-seeded broadleaf weed species, including Amaranthus species. This SC formulation of metribuzin and sulfentrazone is specially formulated into a co-crystalline structure that provides broader crop safety compared to traditional dry metribuzin formulations. Trials in 2025 were conducted across 12 University and Corteva Agriscience™ locations across the eastern and midwestern United States testing labeled rate ranges between 16 and 21 fluid ounces of product per acre (fl oz/a). Results from these trials showed excellent crop safety, with less than 5% general phytotoxicity across all trials and application rates, including at a 2X rate of 42 fl oz/a.

Sulfentrazone is a PPO inhibiting herbicide that is primarily used for preemergent weed control and is flexible for fall burndown applications leading into field corn. Metribuzin is a Photosystem II inhibiting herbicide that is an industry standard for burndown and preemergent weed control on small-seeded broadleaf species and residual efficacy on winter annual species. In this 2025 data, Sonic Boom® at 18 fl oz/a showed >90% residual control of *Amaranthus* species at 4-5 weeks after application across 8 locations. Residual control greater than 95% was observed on common lambsquarters (*Chenopodium album*) populations at 2 locations at 4-5 weeks after application at all rates tested, as well as >85% control of velvetleaf (*Abutilon theophrasti*) populations across 5 locations. Sonic Boom® has shown good tank-mix compatibility due to its unique formulation and has the flexibility to fit a variety of agronomic and weed control systems and two-pass soybean herbicide programs. Corteva Agriscience™ launched Sonic Boom® in 2025 and looks forward to expanding 2026 to aid growers in their weed challenges and support responsible herbicide resistance management.

™® Trademarks of Corteva Agriscience and its affiliated companies

180 - Vyconic Soybeans: A Flexible Approach to Preemergent Weed Management with Acetochlor-Mesotrione Premix

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

[1]Bayer Crop Science

Vyconic™ soybeans 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 an acetochlor plus mesotrione premix product for preemergent use in Vyconic™ soybean. A preliminary update on this product's development will be given featuring preemergent performance data from field trials. Given the increasing challenge of managing herbicide-resistant weeds, Vyconic™ soybeans will provide growers with more choice and flexibility in their herbicide programs.

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

Jody Gander[1], Katilyn Price[1], Carl Coburn[1], Zewei Miao[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. Bayer Crop Science is developing Convintro™, a herbicide technology that features the active ingredient diflufenican which is a Group 12 phytoene desaturase (PDS) inhibitor site of action. While diflufenican has been used in other countries for several years, it's introduction to North America will offer growers a new active ingredient for control of *Amaranthus* spp. in corn and soybean production systems, pending EPA approval. 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.* and crop selectivity in soybean and corn. A preliminary update on diflufenican development will be given featuring performance data from field trials. Pending registration with the U.S. EPA, diflufenican would enable a new weed management tool that should be used in combination with other integrated weed management practices.

182 - Utilization of metribuzin for waterhemp (*Amaranthus tuberculatus*) management in corn

Eric Jones[1], Jill Alms[1], David Vos[1], Tommy Butts[2], Leonard Piveta[2], Alyssa Essman[3], Anthony Dobbels[3], Wesley Everman[4], Damian Frazenburg[4], Alex Macvilay[4], Aaron Hager[5], Joseph Ikley[6], Rodrigo Werle[7], Ryan DeWerff[7]

[1]South Dakota State University, [2]Purdue University, [3]Ohio State University, [4]Iowa State University, [5]University of Illinois, [6]North Dakota State University, [7]University of Wisconsin

Field experiments were conducted at nine locations across the Nort Central region (Illinois, Indiana, Iowa, North Dakota, Ohio, South Dakota, and Wisconsin) during the 2025 growing season 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 38 to 88% with the tested metribuzin rates. Both atrazine rates provided approximately 40% waterhemp control, on average. Average corn yield ranged from 11,702 to 13,113 kg ha^{-1} with the tested metribuzin rates. Corn treated with atrazine at 560 g ai ha^{-1} yielded the same as corn treated with metribuzin at 70 g ai ha^{-1}, but yield was less than the corn treated with greater metribuzin rates. Corn yielded similar or greater than all tested metribuzin rates when treated with atrazine at 1120 g ai 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.

183 - Weed control efficacy and crop safety of Interline® Mega (Glufosinate-P) herbicide programs in glufosinate-tolerant soybean

Ryan Bryant-Schlobohm[1], Ryan Henry[1], Matthew Jenkins[1], Kathryn Ruddy[1], Cody Gray[1]

[1]UPL NA, Inc.

Herbicide resistance necessitates a comprehensive weed management program. The use of herbicide-tolerant crops allows for added diversity to the chemical control methods of a weed management program. Glufosinate-P-ammonium is a refined and herbicidally active isomer of racemic Glufosinate-ammonium. UPL NA, Inc. has developed Interline Mega, a 267 g/L formulation of Glufosinate-P-ammonium for use on several glufosinate-tolerant crops. Interline Mega is pending EPA registration. The objectives of the employed field trials were to evaluate the weed control efficacy and crop safety of

Interline Mega in common post-emergence soybean weed control programs. Results demonstrated performance and agronomics comparable to glufosinate-ammonium, confirming the ability of Interline Mega to contribute to the integrated management of troublesome weed species upon receiving federal registration in the US.

184 - Optimized Herbicide Solutions for Effective Control of Multiple Herbicide Resistant *Amaranthus*

Scott Cully[1], David Belles[1], Mark Kitt[1], Jesse Haarmann[1], Tom Beckett[1]

[1]Syngenta Crop Protection, Greensboro, NC

Waterhemp (*Amaranthus tuberculatus* [Moq.] Sauer.) and Palmer amaranth (*Amaranthus palmeri* S. Watson) are troublesome weed species in corn production due to the selection of populations with multiple resistance to herbicides commonly adopted for their control. Field trials were conducted over several locations with resistance to multiple modes of action in 2024 and 2025 to evaluate herbicide programs for the control of resistant *Amaranthus* spp. populations on LibertyLink® corn and Roundup Ready® Corn 2 technology. Results show that two-pass integrated weed management programs consisting of preemergence followed by postemergence herbicide applications provide effective control of multiple herbicide-resistant *Amaranthus* spp. in LibertyLink and Roundup Ready Corn 2.

185 - Epyrifenacil (Rapidicil®) Tank-Mixes for Cover Crop Termination (Cereal Rye and Wheat) in No-Till Soybean and Corn Production

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

[1]Valent USA LLC

The recent increase in adoption of cover crops such as cereal rye (*Secale cereale L.*) and winter wheat (*Triticum aestivum L.*) for weed suppression and soil health benefits has led to several management challenges. This includes effectively terminating cover crops prior to planting an annual cash crop. Current herbicide termination strategies typically include glyphosate +/- 2,4-D and a residual herbicide for preemergence control of summer annual weeds. However, under cooler environmental conditions, cover crops terminated with glyphosate may take more than 21 days or have less than desired termination creating problems with planting, or competition in the cash crop. *Rapidicil*® (epyrifenacil) is a novel, fast acting PPO-inhibitor currently being developed by Valent U.S.A. LLC for preplant burndown uses in corn, soybean, wheat, and non-crop areas/industrial vegetation management.

The objective of these trials was to measure speed and thoroughness of termination of cereal rye and winter wheat when *Rapidicil* is tank-mixed with glyphosate and with or without residual herbicides. From 2022 through 2025 termination trials of cereal rye and winter wheat were initiated across the United States. Cereal rye or winter wheat were allowed to grow between 25 cm to 1.25 m with the application taking place approximately 7-14 days ahead of anticipated cash crop planting date. Treatments included glyphosate + 2,4-D, *Rapidicil* at 20 g ai ha^{-1}+ glyphosate, *Rapidicil* at 20 g ai ha^{-1}+ glyphosate + flumioxazin, V-10488 at 200 g ai ha^{-1} + glyphosate, and saflufenacil 25 g ai ha^{-1} + glyphosate.

Across all locations, *Rapidicil* + glyphosate combinations resulted in more effective termination of wheat (93%) at 7 days after treatment (DAT) compared with glyphosate + 2,4-D (56%) and saflufenacil + glyphosate (75%). The same differences occurred for cereal rye termination at 7 DAT with *Rapidicil* + glyphosate combinations resulting in 89% burndown compared with glyphosate + 2,4-D (61%) and saflufenacil + glyphosate (66%). Tank-mixing *Rapidicil* containing products with glyphosate to terminate cover crop grass species can increase speed of termination and reduce potential cover crop interference in cash crop production. *Rapidicil* is currently under review and pending EPA registration.

186 - Epyrifenacil (Rapidicil®) Programs for Burndown Weed Control in No-Till Corn, Soybeans, and Wheat

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

[1]Valent USA LLC

Epyrifenacil (Rapidicil®) is a novel PPO-inhibitor currently being developed as a preplant burndown herbicide by Valent U.S.A. LLC. *Rapidicil* demonstrates unique characteristics compared to other PPO's, as it can be translocated via both the xylem and phloem. At a rate range of 20 to 40 g ai ha^{-1}, *Rapidicil* has exhibited fast-acting broad-spectrum control of both broadleaf and grass weed species. Currently, commercialization of *Rapidicil* is focused on preplant burndown uses in corn, soybean, wheat, and non-crop areas/industrial vegetation management. Field and greenhouse trials conducted with *Rapidicil* throughout the United States have shown control or suppression of more than 70 broadleaf and grass weeds. With the increase in weed resistance to herbicides, mixtures of Rapidicil with other effective modes of action will be required. Valent has evaluated control of key winter annual and summer annual weeds during the development of Rapidicil including but not limited to common chickweed (*Stellaria media* (L.) Vill.), dandelion (*Taraxacum officinale* F. H. Wigg.), henbit/purple deadnettle (*Lamium* spp.), kochia (*Kochia scoparia* (L.) Schrad.), common lambsquarters (*Chenopodium album* L.), waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer), downy brome (*Bromus tectorum* L.), wild oat (*Avena fatua* L.), and Foxtails (*Setaria* spp.). Numerous mixture combinations have been evaluated to confirm efficacy against proposed labeled weeds including with glyphosate, glufosinate, dicamba, 2,4-D as well as mixtures with residual herbicides such as flumioxazin and pyroxasulfone. *Rapidicil* is pending EPA registration and not available for sale.

Weed Genetics & Herbicide Physiology / Weed Biology & Ecology

187 - Herbicide Resistance Linked to a New PPO2 Mutation in Michigan Populations of *Ambrosia artemisiifolia*

Sara Alvarez Rodriguez[1], Michael Ozolins[1], Aimone Porri[2], Eric Patterson[1]

[1]Michigan State University, [2]BASF SE, Limburgerhof, Germany

Ambrosia artemisiifolia L. (common ragweed) is an increasingly problematic broadleaf weed in Midwest cropping systems. Following reports from Michigan soybean growers of reduced control with Group 14 protoporphyrinogen oxidase (PPO)-inhibiting herbicides, seed samples were collected from suspected resistant populations and screened under greenhouse conditions. To assess resistance levels, dose-response assays were conducted on three populations (Ambel2021, Ambel61, Ambel62), using sulfentrazone at rates up to 16x the field rate (1x = 420 g ha^{-1}).

LD50 values (rate required to kill 50% of plants) were 151.2, 5,712, and 3,822 g ha^{-1} for the susceptible (Ambel2021), resistant 1 (Ambel61), and resistant 2 (Ambel62) populations, respectively, corresponding to 0.36x, 13.6x, and 9.1x field rate. Biomass-based ED50 values (herbicide rate required to reduce biomass by 50%) were 5.04, 336, and 210 g ha^{-1}. Resistance indices (calculated as the ratio of the ED50 or LD50 of the resistant population relative to the susceptible population) ranged from 25x to 67x, confirming high levels of resistance to sulfentrazone.

To investigate the underlying mechanism, leaf tissue was collected from surviving individuals and genomic DNA was extracted using a CTAB-based protocol. Long-read Nanopore sequencing of the *PPO2* gene revealed the presence of the known R98L mutation and a novel R98Q substitution, both located at codon 98. This residue corresponds to a well-known hotspot for PPO-inhibitor resistance. Structural modeling and docking simulations using AlphaFold3-predicted PPO2 protein structures suggested that the presence of R98Q mutation reduces herbicide binding affinity.

To validate the functional impact of this substitution, PPO2 variants (wild-type and R98Q) were expressed in *E. coli*, and in vitro enzyme inhibition assays were performed against 14 PPO-inhibiting herbicides. Results confirmed that the R98Q variant significantly reduces sensitivity to sulfentrazone, among other herbicides. Ongoing greenhouse studies are evaluating the herbicide resistance levels to additional Group 14 herbicides.

188 - A rearranged Amaranthus palmeri extrachromosomal circular DNA confers resistance to glyphosate and glufosinate

Eric Patterson[1], Pamela Carvalho-Moore[2], Ednaldo Borgato[1], Luan Cutti[3], Aimone Porri[4], Ingo Meiners[4], Jens Lerchl[4], Jason Norsworthy[2]

[1]Michigan State University, [2]Unviersity of Arkansas, [3]Corteva Agriscience, [4]BASF

Some herbicide-resistant weeds become resistant by generating additional copies of specific loci. For example, amplification of the locus encoding *chloroplastic glutamine synthetase* (*GS2*) produces herbicide resistance in the glufosinate-resistant Palmer amaranth (*Amaranthus palmeri*) accession MSR2. Previously, overamplification of the glyphosate-resistant gene encoding *5-enolpyruvylshikimate-3-phosphate synthase* (*EPSPS*) in Palmer amaranth was determined to be driven by an extrachromosomal circular DNA (eccDNA). Here, we describe a rearranged eccDNA that confers resistance to both glyphosate and glufosinate ammonium due to the coduplication of the native chromosomal regions that contain the genes that encode for these herbicides target proteins. In addition to *EPSPS*, the replicon carries 2 *GS2* isoforms (*GS2.1* and *GS2.2*) and other genes. MSR2 samples harbored eccDNA carrying only *EPSPS* coexisting with eccDNAs harboring both *EPSPS* and *GS2*. A second glufosinate-resistant Palmer amaranth accession (MSR1) showed distinct *GS2.1* and *GS2.2* amplification patterns from MSR2,

suggesting the existence of diverse replicons in Palmer amaranth. *EPSPS* copy number was correlated with both *GS2* isoforms copy number in MSR2, further supporting the coexistence of these genes in the same replicon. These findings shed light on the complexity of eccDNA formation in plant systems, with the collection and accumulation of extra pieces of DNA.

189 - Distinct and Shared Gene Expression Signatures Induced by 2,4-D, Dicamba and Glyphosate Herbicides in Non-GMO Soybean

Akanksha Singh[1], Julie Young[1], Bryan Young[1]

[1]Purdue University, West Lafayette, IN

Soybean [*Glycine max* (L.) Merr.] is a vital crop for global food and feed production, with herbicides such as 2,4-D, dicamba and glyphosate used extensively to control weeds and maintain yield potential. In previous research, high-precision spatial and spectral imaging identified herbicide induced damage at 24 hours after treatment despite a lack of visible plant response. Research was conducted to obtain deeper insights into the underlying molecular responses associated with early plant response to herbicides. An RNA-seq transcriptomic analysis via Illumina sequencing was conducted to examine the differentially expressed genes (DEGs) after 2,4-D, dicamba and glyphosate treatment at V2 growth stage of soybean. A total of 7,538, 2,536, and 1,215 DEGs were identified in the glyphosate vs. mock, 2,4-D vs. mock, and dicamba vs. mock comparisons, respectively, of which 2,768, 129, and 12 were significantly differentially expressed. Gene ontology (GO) and Kyoto Encyclopedia of Genes and Genomes (KEGG) enrichment analysis, showed most of the DEGs were annotated to the lipid metabolism, phenylpropanoid biosynthesis, oxidation-reduction pathways, hormone signaling, defense responses, and glycosyltransferase activity. Some of the candidate genes viz., *CYP450*, *ABC* transporters and *GST*, found to be differentially regulated in all three herbicides are known to detoxify herbicide molecules through physical or biochemical processes. Additionally, cell wall biosynthesis genes, hormone -related and lipid -related genes which play an important role in herbicide tolerance were significantly upregulated. These findings provide molecular insights into herbicide-induced responses that form the unique imaging signatures of these herbicides on soybean.

190 - Reduced Mesotrione Metabolism Enhances Grain Sorghum Injury under High Temperature Stress

Yasir Parrey[1], PV Vara Prasad[1], Mithila Jugulam[2]

[1]Kansas State University, [2]Texas A&M

Effective post-emergence (POST) weed control is essential for maximizing grain sorghum productivity; however, high-temperature (HT) stress can adversely affect crop tolerance to herbicides. Previous studies have suggested that HT stress increases mesotrione injury in sorghum. This study aimed to investigate the physiological basis of sorghum injury from mesotrione under high-temperature (HT) stress. Grain sorghum genotypes were grown in two separate growth chambers maintained at either optimum temperature (OT) of 32/22°C or high temperature (HT) of 40/30°C conditions. At 4-5 leaf stage, a mixture of radiolabeled [14C]- and unlabeled mesotrione was applied separately to the fourth youngest leaf of each plant. Foliar uptake, translocation and metabolism were quantified at 6 and 24 hours after treatment (HAT), and cytochrome P450 (CYP450)-mediated metabolism was assessed using malathion as an inhibitor. Herbicide uptake increased under HT, but most of the absorbed mesotrione remained in the treated leaf, likely due to reduced CYP-mediated metabolism, leading to greater injury. HPLC results showed greater amount of parent mesotrione in the plant under HT in comparison to OT possibly due to reduced metabolism. The CYP450 inhibitor assay further confirmed that mesotrione metabolism was suppressed under HT, indicated by significant biomass reduction when mesotrione was applied in combination with malathion. Overall, HT enhanced herbicide uptake but differentially affected the metabolism and distribution of mesotrione, thereby influencing the extent of crop injury. These findings demonstrate that mesotrione responds differently to temperature stress in terms of uptake, metabolism, and resulting crop injury. Therefore, selecting the appropriate herbicide and sorghum genotype is critical for minimizing injury and maintaining weed control efficacy, particularly under projected increases in global temperature.

191 - Environmental by Genotypic Drivers of *Parthenium hysterophorus* Photosynthesis and Phenotypic Plasticity

Sarah Kezar[1], Akhilesh Sharma[2], Magdalena Julkowska[2], Tim Setter[2], Antonio DiTommaso[2]

[1]University of Wisconsin-Madison, [2]Cornell University

Parthenium hysterophorus is an annual weed of global significance, beyond its native range from the southern region of North America to the northern parts of South America. This study investigates how abiotic stress influences global genotypes of *P. hysterophorus* through traits associated with weedy adaptation and photosynthetic pathways (C3 and C4-like characteristics) that may enhance its survival and competitiveness. Genotypes of *P. hysterophorus* were sourced from the native range (Corpus Christi, Texas, USA, and Texcoco, Mexico) and non-native ranges (South Africa, Australia, Vietnam, and Pakistan). The experiment was conducted over two experimental runs in a completely randomized design with five biological replications within a growth chamber at the Boyce Thompson Institute (BTI) Phenotyping Facility at Cornell University. Plants were exposed to two temperature regimes—optimal (25/18°C day/night) and elevated (35/28°C day/night), combined with ambient (430 ppm) or elevated (730 ppm) CO_2 levels. At the 8-leaf rosette stage, half of the plants underwent a 14-day drought stress period. Daily plant weights were recorded to guide watering and calculate evapotranspiration. High-throughput imaging was performed twice daily during the drought period, capturing RGB data and physiological metrics including maximum quantum yield of PSII (Fv/Fm), electron transport rate (ETR), anthocyanin index, and NDVI. After the drought period, plants were re-watered and monitored for 21 days to assess recovery, with additional photosynthetic measurements taken. This study aims to determine whether fitness responses correlate consistently with phenological or architectural traits, exploring whether trait plasticity reflects a "Jack-of-all-trades" or "Jack-and-master" strategy. These insights may help clarify the adaptive significance of trait variation in successful invasions.

192 - Performance of remote sensing for predicting Palmer amaranth and grain sorghum interference outcomes in dryland production systems of western Kansas

Jeremie Kouame[1], Augustine Obour[1], Deepak Joshi[1], Anita Dille[1], Johnathan Holman[1], Taylor Lambert[1], Olumide Daramola[1], Atong Akom[1]

[1]Kansas state university

Early weed detection and integrated weed management strategies are essential for controlling multiple herbicide-resistant (MHR) weeds such as Palmer amaranth [*Amaranthus palmeri* S. Watson]. A quantitative understanding of weed interference with crops could help develop effective integrated weed management strategies that enhance crop competitiveness, reduce weed emergence, growth, and seed production. However, crop-weed interference studies present multiple challenges, including the need for a substantial amount of data from studies conducted across various dates and environmental conditions. Commonly used predictors for assessing crop-weed interference outcomes include weed density, weed density and emergence time relative to the crop, and weed relative leaf area, with the latter often considered a better predictor. Unfortunately, collecting and processing crop and weed leaf area data for these studies can be labor-intensive. The introduction of novel technologies into the weed science discipline could provide new opportunities for crop-weed interaction research and enhance management strategies. Can remote sensing data from drone-based RGB and multispectral imagery help predict the outcomes of grain sorghum [*Sorghum bicolor* (L.) Moench] and Palmer amaranth interference in no-till dryland production systems? This presentation will involve the discussion of observations from ongoing research.

193 - Environmental and genetic factors shaping seasonal life cycle type in horseweed (*Erigeron canadensis*)

Robin Waterman[1], Brooke Catlett[1, 2], Ishwari Bhatt[1, 3], Georgia Edmonds[1, 3], Jeffrey K. Conner[1]

[1]Kellogg Biological Station and Department of Plant Biology, Michigan State University, Hickory Corners, MI 48823, [2]Department of Plant Biology, Southern Illinois University Carbondale, Carbondale, IL, 62901, [3]Kalamazoo Area Mathematics and Science Center, Kalamazoo, MI, 49008

Facultative winter annual weeds can adopt either a fall-emerging/spring-flowering or spring-emerging/summer-flowering life cycle at the population level via evolution or at the individual level via plasticity. However, the environmental and genetic factors shaping such life cycle differentiation are not well-understood in most species. We conducted growth chamber and greenhouse experiments using horseweed (*Erigeron canadensis*) to investigate the interactive effects of genetic variation; transgenerational responses to parent plant life cycle; and plastic responses to temperature, light, and Gibberellic Acid growth hormone treatments. We found that contrary to a prior report, exposing imbibed seeds to 3-4 weeks of cold (i.e., seed vernalization) does not always result in summer annual type growth, with considerable variation found among field-collected seeds from 10 populations. Further, seed vernalization and exogenous application of GA both tended to increase summer annual characteristics, interacting in ways that were largely consistent with the hypothesis that GA is a mechanism for cold-induced life cycle differentiation. Light treatment, parent life cycle type, and genetic variation among and within sites explained little variation in life cycle traits. Overall, our study proposes that the seasonality of this harmful agricultural weed is influenced by a GA-mediated response to vernalization of seeds during winter, yet highlights the need for further study, given the variability in this response.

194 - Comparative Performance of Conventional and Short-Stature Corn Hybrids in Wisconsin: Canopy Development, Weed Suppression, and Yield

Ahmadreza Mobli[1], Harkirat kaur[1], Ryan Dewerff[1], Luma Lorena Loureiro Da Silva Rodrigues[1], Daniel Qiran Zhu[1], Rodrigo Werle[1]

[1]University of Wisconsin- Madison

Short-stature corn hybrids represent a recent advancement in corn breeding, developed to improve standability and reduce lodging risk under dense planting conditions and high winds. However, their agronomic performance compared with conventional hybrids, particularly in relation to canopy development, light interception, and weed suppression, remains understudied. A field experiment was conducted in 2024 at two locations (A and B) at the Arlington Agricultural Research Station (Arlington, WI) using a factorial design with eight hybrids (four conventional and four short-stature) and two weed management systems (weed-free and weedy after V4-V5), arranged in a randomized complete block design with four replications. All hybrids reached 50% canopy height development at the V12 stage at Arlington 2024-A and at the V10 stage at Arlington 2024-B. Except for the PR108-20SSC hybrid, short-stature hybrids exhibited 14%-16% shorter maximum plant height than conventional hybrids. No differences were observed among hybrids for maximum light interception and the growth stage where 50% light interception occurred. End-of-season weed biomass was not different among hybrids. Conventional hybrids 207-87VT2P RIB and 207-27STX RIB in Arlington-2024 A, and hybrids 206-40VT4P RIB and 207-27STX RIB in Arlington-2024 B, provided the greatest yield compared to all other hybrids. These findings indicate that while short-stature hybrids differ in plant height, their light interception dynamics are similar to those of conventional hybrids, with only minor yield differences observed in this study depending on hybrid and environment. These findings highlight the opportunity for further agronomic research on short-stature corn hybrids to maximize yield potential while leveraging the benefits this trait offers to corn production systems.

195 - Evaluating the Evolutionary Stability of Dioecy in the Genus *Amaranthus*

Alexander Lopez[1], Lucas Bobadilla[1], Damilola Raiyemo[1], Isabel Werle[1], Patrick Tranel[1]

[1]University of Illinois

Despite the dioecious, obligately outcrossing nature of Palmer amaranth (*Amaranthus palmeri* S. Watson) and waterhemp [*A. tuberculatus* (Moq.) Sauer], recent evidence suggests that some individuals may self-reproduce. However, the mechanism (e.g., agamospermy or sex lability) and frequency of this phenomenon remain unclear. Therefore, this study aimed to determine (1) how frequently self-reproduction occurs, (2) by what mechanism it occurs, and (3) its potential to increase under selection. To accomplish this, plants from multiple populations of each species were grown in isolation from the

opposite sex, and progeny from seed-producing individuals were selectively propagated for up to three generations. Self-seed production was observed in female plants of both species, with waterhemp (~50%) showing a higher frequency than Palmer amaranth (~12%). However, seed output increased significantly over generations only in waterhemp. Nearly complete feminization was observed among progeny in both species, except for one waterhemp individual, which exhibited clear sex lability (male and female structures). This phenotype did not appear to be maintained in its offspring, though it would be difficult to detect a low frequency of male flowers. Interestingly, some Palmer amaranth males (~10%) also produced seeds, and sex lability became clearly more common in subsequent generations, resulting in substantial seed production. Whole-genome sequencing across generations revealed a pronounced loss of heterozygosity, consistent with repeated selfing. Together, these results indicate that self-seed production arises from self-fertilization of sex-labile individuals in these populations. Under the pressure of mate limitation, the frequency and magnitude of sex lability may rapidly increase, potentially leading to the breakdown of dioecy.

196 - Waterhemp Management in Early Planted Soybean- What We've Learned the Past Five Years

Aaron Hager[1], Logan Miller[2]

[1]Professor, [2]Research Specialist

The potential to maximize soybean yield by planting earlier than conventionally done warrants research to investigate different preemergence (PRE) and postemergence (POST) combinations for waterhemp (*Amaranthus tuberculatus*) control. The objective of this research was to evaluate: (1) soybean planting date, (2) PRE herbicide selection, and (3) layered residual on waterhemp control, density, and biomass. Field studies were conducted in Illinois at one site in 2023, two sites in 2024, and three sites in 2025 in two different soybean planting timings (early vs. conventional). PRE treatments were applied at 1x label recommended rates at planting while POST treatments included an early POST plus a soil-residual herbicide (EPOST + R), and a mid-POST (MIPOST) timing with and without a soil-residual herbicide. The EPOST was applied at 28 days after planting (DAPL) and the MIPOST was applied when waterhemp reached 10 cm tall. Early planting resulted in greater waterhemp density compared to the conventional planting date at the MIPOST timing (25 plants m^{-2} compared to 16 plants m^{-2}) and at soybean maturity (5 plants m^{-2} compared to 1 plant m^{-2}). PRE herbicide did not significantly influence waterhemp control or density at soybean maturity. In contrast, the EPOST+R for both planting dates resulted in significantly greater waterhemp density and reduced control at maturity compared to the MIPOST timing. Despite improved waterhemp control with the MIPOST timing, further management tactics are warranted to provide season-long control of waterhemp in early planted soybean.

Graduate Student *Symposium* – Building Your Future: Career Development & Interview Strategies

197 - Building Your Future: Career Development and Interview Strategies - Introduction

Cristiana Rankrape[1], Abigail Norsworthy[2]

[1]Southern Illinois University, [2]Purdue University

The future of weed science relies on the development of well trained, adaptable professionals prepared to meet the challenges of an evolving field. As students transition from graduate school to their professional careers, the ability to communicate effectively, build professional identity, and make informed decisions becomes increasingly important. To address these needs, the Graduate Student Organization (GSO) has organized a symposium focused on career development and interview strategies. The objectives are to expose students to diverse career trajectories and stages, address common challenges associated with early career advancement, and equip students with practical strategies for transitioning from graduate school into the workforce. Presentations will highlight strategies for building a successful academic program, establishing credibility in extension, setting yourself up for success in an industry position, and advocating for weed science at the national level. A session on interview preparation will demonstrate strategies for effective communication and provide insight into the hiring process. The symposium will conclude with a mock interview exercise, allowing participants to observe a variety of interviewing techniques. With insights from experienced professionals, this symposium aims to provide students with the tools, confidence, and perspective needed to successfully launch their careers and strengthen the next generation of leaders in weed science.

198 - Building an Academic Program that Lasts

Bryan Young[1], Thomas Butts[1]

[1]Purdue University

Abstract not available.

199 - Extension 101: Building Trust, Relevance, and Reach

Rodrigo Werle[1]

[1]University of Wisconsin - Madison

Extension plays a vital role in weed science by connecting research with growers and stakeholders to promote effective management practices and research adoption. This presentation will share my journey into extension, beginning in a farming community in Brazil, where I developed an early interest in agronomy and crop consulting. While pursuing a Bachelor's degree in agronomy, I discovered a passion for research that led me to the U.S. as a visiting scholar, where I first experienced the Land Grant mission and the essential role of Extension in agriculture. Through opportunities such as the Nebraska herbicide evaluation program, stakeholder training, and extension presentations, I developed key communication and outreach skills during graduate school. These experiences, along with preparation for the NCWSS Student Weed Contest, were instrumental in shaping my current role as an Extension Weed Scientist. Today, my program focuses on timely, applied research that directly addresses stakeholder needs, which

we routinely assess through surveys to ensure alignment with real-world challenges. Successful extension work goes beyond research, it requires building trust, providing relevant information, and creating engaging experiences. I emphasize being available, approachable, and responsive to growers and their decision influencers, helping them identify practical solutions to weed management challenges. High-quality field events are a cornerstone of our WiscWeeds program, designed to deliver strong research content and a positive overall experience. This includes thoughtful logistics, networking opportunities, and an environment where participants feel valued and heard. In today's digital age, social media has become an indispensable extension tool. Maintaining an active online presence has opened doors for new presentations, collaborations, and outreach opportunities. I am also fortunate to lead a very dedicated research team passionate about the real-world impact of our work and committed to serving the weed management community. Extension work, while rewarding, presents challenges. The time commitment of balancing research and outreach can be demanding, and representing weed management recommendations for an entire state and beyond carries significant responsibility. Integrating extension and applied research is therefore essential to maintain credibility and relevance amid today's information overload. Reliable, data-driven results form the foundation of recommendations that stakeholders can trust. In conclusion, weed science extension is a dynamic and fulfilling career that blends research, communication, mentoring, and service. This presentation will offer practical insights to help graduate students prepare for extension careers, highlighting strategies for building trust, staying relevant, and leveraging both traditional and digital platforms to maximize reach and impact.

200 - Making the Leap from Graduate School to Industry

Samuel Noe[1]

[1]Valent USA

Abstract not available.

201 - Advocating for Weed Science in D.C.

Lee Van Wychen[1]

[1]Weed Science Society of America

Abstract not available.

202 - Unlocking Opportunity: Strategies to Get Noticed, Get Hired

Dawn Refsell[1]

[1]Corteva Agriscience

In today's competitive professional landscape, the ability to stand out is essential for both personal and career growth. Drawing inspiration from the field of weed science to explore how adaptation and resilience can unlock individual potential and foster uniqueness. Through reflection and storytelling,

participants will examine how their own experiences—especially moments of challenge—can be transformed into opportunities for growth and leadership. We will highlight the power of networking as a vital tool for thriving in crowded environments, enabling individuals to amplify their strengths and build meaningful connections. Real-world examples will illustrate how leveraging personal talents can turn setbacks into stepping stones. Whether you're early in your career or navigating a new phase, its never too late to create lasting impact and confidently stand out from the crowd.

203 - Inside Academia: What to Expect in a Faculty Job Interview

Sarah Lancaster[1]

[1]Kansas State University

Abstract not available.

204 - Speaker Panel Q&A

Cristiana Rankrape[1]

[1]Southern Illinois University

Q&A Panel

205 - Mock Interviews

Dawn Refsell[1], Karla Gage[2]

[1]Corteva, [2]Southern Illinois University

Mock Interviews with:

- Nick Steppig - BASF
- Livia Ianhez Pereira - Bayer
- Jose Nunes - Syngenta
- Matthew Jenkins - UPL
- Ryan Edwards - WinField United

Symposium - The Drone Revolution in Weed Science: Market, Science, and Retail

206 - Fundamentals of Drone Sprays for Weed Scientists

Mark Ledebuhr[1]

[1]Application Insight, LLC

Mark will cover the fundamentals of applying spray by drone, which are more complicated than other sprays. We will learn about air and spray interaction, factors that can impact swath and how to easily and effectively measure it, impacts of evaporation that need to be considered, and other implications for doing plot research with drones.

207 - Drone Speed Dating - A Summary of Four Years of Research

Jason Deveau[1]

[1]Ontario Ministry of Agriculture, Food and Agribusiness (OMAFA)

Interest in rotary drones for broadcast spraying continues to increase exponentially. Drones are relatively inexpensive, easy to use and potentially lucrative, so there’s a new generation of operators that have never flown and have never sprayed, employing a technology we’re still trying to understand. For the last four years we have studied the impact of changing operational parameters such as speed, altitude, droplet size, and volume on coverage and drift. We’ve explored effective swath in several broadacre and specialty crops, in wind and in calm. The resulting recommendations inform basic best practices for rotary drones for new and experienced pilots.

208 - Drones: Finding their Fit on the Farm

John Scott[1]

[1]Keystone Cooperative

This discussion will cover some regulations/legal hurdles and divulge practical lessons learned from this evolving technology. Along with providing insights into using camera drones for more than scouting fields and are sprayer drones the future or just a fad?

209 - Understanding Federal Regulations for Spray Drones

Alex Ryan[1]

[1]Agrispray Drones

Abstract not available.

210 - Laboratory Method Development, Challenges, and Open Questions in Drone Spray Measurements

Steven Fredericks[1], Matthew Rogers[1], Sawyer Massie[1]

[1]Winfield United

The adoption of spray drones as a weed management tool has increased year over year, with the greatest adoption of air frames using rotary atomizers rather than hydraulic nozzles. The emergence of this tool gives greater flexibility for applicators to allow for more timely management activities, however there is currently a lack of sound methods for characterizing these sprays to inform weed management decisions and regulatory guidance on registered crop protection products. This presentation highlights the attempts to develop novel laboratory methods as well as adapt existing droplet sizing methods to characterize drone sprays, as well as discusses the open questions that are yet to be resolved in order to interpret laboratory spray measurements to predict field outcomes.

211 - Drone Applications- The Good, The Bad, and The Ugly

Dean Grossnickle[1], Neill Newton[1], Blake Patton[2], Phil Krieg[1], Scott Cully[1]

[1]Syngenta Crop Protection, Greensboro, NC, [2]Rend Lake College, Ina, IL

Agricultural application drones continue to increase in number and use. Many of these drones are equipped with rotary atomizers that create droplets differently than a traditional nozzle and flight parameters like altitude, speed, and rotor wash help dictate the swath width. Proper calibration and drone set up are essential to crop protection product performance. As a basic manufacturer of crop protection products, Syngenta is helping to educate applicators with proper drone calibration as well as passing along key insights for more effective product usage.

212 - Will Spray Drones Work for Herbicide Applications? Well, the Weeds are Dead

Bryan Young[1], Hunter Medenwald[1], Julie Young[1], Thomas Butts[1]

[1]Purdue University

Abstract not available.

213 - Capabilities and Viability of Drones in our Weed Science World

Thomas Butts[1], Maria Souza[1], Emmanuel Cooper[1], Cason Estevan[1], Leo Piveta[1], Julie Young[1], Bryan Young[1]

[1]Purdue University

This presentation will cover the use of both spray and imaging drones for weed science related principles. Results and recommendations generated from multiple research projects conducted will be used to demonstrate the potential of these technologies, how they might be integrated into our research and Extension programs, and their commercial viability. Over the past few years, numerous aspects have been evaluated for understanding spray drone applications including droplet size, adjuvant use, spray carrier volume, spray drone platform, and intended swath width. As a result of these testing procedures, application outcomes such as effective swath widths, droplet size deposition, spray coverage, and active

ingredient deposition, will be discussed for a better understanding of herbicide application dynamics from spray drones. Weed control will also be presented to understand the potential of spray drone implementation for effective weed management programs. Imaging drones have also been evaluated in numerous projects for their potential in herbicide crop injury quantification, weed control determination, and weed detection for use with targeted applications. Resolution requirements, various vegetative indices, and multiple software programs have been investigated for ease of implementation and accuracy. These imaging tools can help reduce labor needs, expedite scouting efforts, and provide quantitative data for injury and control assessments. Knowledge gleaned from this presentation will aid in implementing drones into our weed science world, as well as a better understanding of best use practices to optimize their usage immediately.

214 - 20X faster drone imaging for full field weed detection and classification

Todd Colten[1]

[1]Sentera / John Deere

Sentera's PixelScout drone imaging system captures ultra-high resolution imagery covering every inch of a field with 1.5mm pixel resolution imagery 20X faster than traditional drone imaging. Sentera's FieldAgent software and SmartScript AI algorithms detect and classify weeds and crops, gathering prior knowledge to inform herbicide application decisions and targeted spray programs.

215 - Aerial Imagery: Automated & Elevated Analytics for Field Research

Jeremiah Roeth[1]

[1]AerialPLOT

UAV-based aerial imagery, coupled to robust pixel-based image analytics and computer vision models, offers enormous potential to enhance field research trials. A variety of sensors and analytics techniques can be leveraged to systematically quantify properties of complex canopies, generating digital phenotypes describing crop physiology as well as the identification of target plant species. These methods are highly automatable and reproducible, resulting in temporal geospatial datasets for improved accuracy, cumulative metrics, and rate-of-change dynamics to give a complete picture of crop responses. Current practices and cloud-based software solutions will be discussed using real-world case studies.

Horticulture & Specialty Crops

216 - Golden Pennycress Response to PRE, POST and Desiccant Herbicides

Mark Bernards[1], Carrie Eberle[2], Ryan DeWerff[3], Ahmadreza Mobli[3], Rodrigo Werle[3]

[1]Rosens, Inc., Alexandria, MN, [2]USDA-ARS, Morris, MN, [3]University of Wisconsin-Madison, Madison, WI

Golden pennycress is domesticated field pennycress (*Thlaspi arvense*) characterized by a yellow seed coat, lack of seed dormancy, and reduced erucic acid. One anticipated use of this new winter annual crop is as a feedstock for sustainable aviation fuel. Golden pennycress may be planted in the fall (mid-September to early-October, North to South), and harvested in the spring (late-May to early-July, South to North). One herbicide (quizalofop) has received a label for use in pennycress through the IR-4 program. The objective of this research was to identify additional herbicides that may be selective for pennycress and provide future growers with chemical options for weed management in-crop. Field studies were conducted to evaluate 1) pennycress response to herbicides applied preemergence, 2) pennycress response to herbicides applied postemergence, and 3) pennycress response to desiccants applied to hasten drydown. Research trials were conducted in Macomb, Illinois (objective 1), Morris, Minnesota (objectives 1-3); and Arlington, WI (objective 3) between 2022-2025. Preemergence herbicides were applied shortly after planting in the fall of 2022, 2023, and 2024. Herbicides applied preemergence that caused limited injury (<10%) and no yield loss in pennycress included trifluralin, ethalfluralin, and clopyralid. Herbicides applied preemergence that caused some injury (<30%) and no yield loss included s-metolachlor, acetochlor, dimethenamid, flufenacet, and reduced rates of pyroxasulfone, topramezone, and tolpyralate. In one year (2022), pendimethalin caused significant injury and yield loss. Postemergence herbicide applications were made in late April after growth resumed but prior to pennycress bolting. In the spring of 2024, no visual injury was detected for any of the herbicides applied (s-metolachlor, acetochlor, dimethenamid, pyroxasulfone, clopyralid, quizalofop, clopyralid, and quinclorac). In the spring of 2025, clopyralid and pyroxasulfone caused minor injury. None of the herbicides applied postemergence reduced yield relative to the untreated control. The target application timing for desiccant treatments was at physiological maturity (growth stage 8.4-8.8), which is reported to occur when 40-80% of the pods are yellow. Diquat hastened drydown rapidly, resulting in maturity ratings of 9.6 (nearly all plants a uniform grayish tan) within 3 days of application, and reduced seed moisture at harvest. Saflufenacil did not hasten maturity nor did it reduce seed moisture relative to the untreated. In the trials conducted in 2024 desiccants were applied at stage 8.4 or 8.5, and none of the desiccant treatment applications affected seed yield or seed germination. In one of the trials conducted in 2025 desiccants were applied at stage 8.2, and diquat reduced seed yields more than 40%. These studies provide evidence to support further evaluation of herbicides for use in pennycress. They also provide evidence that when these herbicides are used in a crop that precedes a fall planting of pennycress they are unlikely to cause injury to the pennycress. Diquat has potential as a desiccant in pennycress to hasten harvest time, but careful guidance on identifying physiological maturity will be necessary to protect pennycress seed yield.

217 - Integrating Bioherbicides into Palmer amaranth (*Amaranthus palmeri* S. Watson) Control Strategies

Milan Brankov[1], Breno Rodrigues[2], Jeffrey Golus[2], Kasey Schroeder[2], Milos Zaric[2]

[1]Maize Research Institute "Zemun Polje", Zemun Polje, Belgrade, Serbia, [2]University of Nebraska-Lincoln, WCREEC, North Platte, Nebraska, USA

Interest in alternatives to conventional herbicides has increased over the past two decades, driven by global market demand for bio-based herbicide options. However, these products often come with a higher price tag than conventional herbicides and limited guidance for their use, making it essential to test and optimize their efficacy to achieve the highest possible level of weed control. Currently, limited research has been conducted on the response of Palmer amaranth (*Amaranthus palmeri* S. Watson) to bioherbicides, despite its being considered one of the most troublesome weed species worldwide. To address this, six non-selective bioherbicides were evaluated under greenhouse conditions at application doses corresponding to 0.25×, 1×, and 3× of the currently recommended highest field rates for tough-to-control weeds. The bioherbicides tested were ammonium nonanoate, capric and caprylic acid, eugenol, d-limonene, pelargonic acid, and a clove oil + cinnamon oil mixture, each applied on Palmer amaranth when plants reached 10-15 cm -alone or in tank-mixed with a non-ionic surfactant (0.6 L ha^{-1} or 0.15 % v v^{-1}). All treatments have been applied using the DG9503E nozzle set at 50cm height and calibrated to deliver 400 L ha^{-1} at 276 kPa. The study evaluated the percentage of biomass reduction at XX days after application compared to the untreated control. Among the tested products, pelargonic acid provided the highest biomass reduction across all rates, ranging from 82% at 0.25× to 99% at 3×. Ammonium nonanoate and capric and caprylic acid blend showed lower efficacy at 0.25× (59% and 54% without the additive, respectively) but achieved 83 to 98% biomass reduction at higher doses. D-limonene resulted in a biomass reduction of up to 79% in Palmer amaranth, whereas the formulation containing clove and cinnamon oils provided a reduction of up to 69% at the 3× rate. The lowest efficacy was observed for the eugenol-based herbicide, which achieved only 25% and 41% biomass reduction at 1× and 3× rates, respectively. The results indicate the potential for using certain bioherbicides as candidates to achieve satisfactory control of Palmer amaranth. However, considering the non-selective nature of these products, targeted spray applications will be required to enable their practical use in both row and specialty crop production systems.

218 - Icafolin-Methyl - a New Molecule in the Chemical Class (Isoxazolin-Carboxamides) from Bayer CropScience

Angela Kazmierczak[1], Christopher Mansiere[1], Allan Kaastra[1], Lothar Lorentz[1]

[1]Bayer CropScience

Icafolin-methyl is a unique molecule being developed by Bayer CropScience across a broad range of crops (soybean, cereals, pulses, oilseed crops, as well as pome and stone fruits, tree nuts, grapes, and citrus) for preemergent /preplant burndown of difficult to control grass and broadleaf weeds. Icafolin-methyl is classified as a group 23 herbicide in the new chemical class Isoxazolin-Carboxamides. Icafolin interrupts the assimilate transport from source to sink within the plant leading to a starvation of the sink tissue. It also inhibits the meristematic tissues which slowly dies off from either starvation and interrupted cell cycles. Icafolin-methyl will control all known resistant biotypes of proposed labeled weeds and will be used in an integrated weed managment strategy to protect other effective modes of actions and delay the onset of new resistant biotypes. Icafolin-methyl is currently under review and pending registration from the EPA and PMRA.

219 - Evaluating flumioxazin applications to red and chipping potato cultivars

Harlene Hatterman-Valenti[1], Collin Auwarter[1]

[1]North Dakota State University

Potato growers use integrated weed management tools including timely cultivation (hilling), herbicides, and crop rotation to reduce the effects of weed competition on potato yield. Research has shown that without weed control, potato yields would decline by at least 32% due to weed competition, with broadleaf weeds causing the greatest competition. The main herbicide that growers rely on for broadleaf weed control is metribuzin. However, this herbicide does not control nightshade species and has potato sensitivity issues for numerous cultivars that are not russet types. Three years of previous research on 'Russet Burbank' has shown that flumioxazin rate and application timing are important factors contributing to potato injury. The current research evaluated: (TRT 1) flumioxazin (1x) applied immediately after planting (no hilling) followed by a half-rate of metolachlor plus metribuzin after hilling; (TRT 2) flumioxazin applied after regular hilling (labelled use rate); and (TRT 3) metolachlor plus metribuzin applied after regular hilling (grower standard) to three red cultivars (Red, Red Lasoda, and Sangre) and three chipping cultivars (Dakota Pearl, Snowden, and Waneta). Results with the red cultivars indicated that TRT 1 generally had the highest marketable yield even though marketable yield was not significantly different. 'Red Norland' from TRT 1 had a 12% and 21% increase in marketable yield compared to 'Red Norland' from TRT 2 and TRT 3, respectively. Similarly, 'Sangre' from TRT 1 had a 5% and 2% increase in marketable yield compared to 'Sangre' from TRT 2 and TRT 3, respectively, while 'Red Lasoda' from TRT 1 had a 6% increase and 2% decrease in marketable yield compared to 'Red Lasoda' from TRT 2 and TRT 3, respectively. Marketable yield results for the chipping cultivars were mixed. 'Dakota Pearl' from TRT 2 had the highest marketable yield, while for 'Snowden' and 'Waneta', the highest marketable yields were from plants in TRT 3. Further analysis will be conducted to compare results from 2025 with results from 2024.

220 - Sugarbeet Tolerance from Herbicide Mixtures with Insecticides and Fungicides

Adam Aberle[1], Thomas Peters[1], David Mettler[2], Emma Burt[3]

[1]North Dakota State University, [2]Southern Minnesota Beet Sugar Cooperative, [3]Minn-Dak Farmers Cooperative

Sugarbeet (*Beta vulgaris* L.) is among the most expensive crops to cultivate per hectare, requiring a rigorous and precisely timed pest management program to achieve peak root yield and sucrose content. Efficient time management and strategic pesticide use remain primary concerns for sugarbeet producers, as postemergence weed control frequently coincides with management of soilborne and foliar diseases and insects. Three greenhouse and five field experiments were conducted in 2025 to evaluate sugarbeet tolerance to complex mixtures targeting soilborne and foliar diseases. In the field, pesticide treatments were applied with a CO_2-pressurized bicycle sprayer, calibrated to deliver 159 L ha^{-1} through 8002XR nozzles spaced 51 cm apart. Soilborne complex mixture treatments consisted of glyphosate, ethofumesate, and dimethenamid-P applied in combination with inpyrfluxam (FRAC 7) or azoxystrobin (FRAC 11) and with esfenvalerate (IRAC 3A) or clopyralid, singly or combined at maximum use rates at the four- to six-leaf sugarbeet stage. Foliar complex mixture treatments included glyphosate, ethofumesate, and acetochlor applied in combination with mancozeb (FRAC M03) or zeta-cypermethrin (IRAC 3A), singly or mixed with clethodim or prothioconazole (FRAC 3) at maximum use rates at the eight- to ten-leaf sugarbeet stage. Sugarbeet malformation, necrosis, and growth reduction were measured visibly using a 0% to 100% scale, 0% as no response and 100% as complete loss of sugarbeet, at three, seven, and fourteen days after application. Sugarbeet root yield and sucrose content were measured as percent sucrose, root yield as tonnes ha^{-1}, and extractable sucrose as kilograms ha^{-1}. While responses differed between experiments targeting soilborne or foliar diseases, they were consistent across environments within each experiment and analyzed accordingly. Herbicides and insecticides mixed with soilborne fungicides for rhizoctonia (*Rhizoctonia solani* Kühn) control caused sugarbeet malformation, necrosis, and growth reduction ($P<0.05$) three, seven, and fourteen days after application at Prinsburg, MN and Crookston, MN. Herbicides and insecticides mixed with foliar fungicides for Cercospora leafspot (*Cercospora beticola* Sacc.) control had no effect ($P>0.05$) on sugarbeet malformation, necrosis, and growth reduction three, seven, or fourteen days after application at Prosper, ND and Brushvale, MN. Still, leaf burn measured as necrosis was observed although transient. Further, physical tank-mixture incompatibility measured as product separation was not observed with soilborne complex mixtures but was evident with foliar complex mixtures. Mixtures containing water dispersible granules are expected to require greater agitation than those without and should therefore be carefully managed. Sugarbeet root yield and sucrose content were different ($P<0.01$) for soilborne complex mixtures but were the same for foliar complex mixtures. These experiments addressed sugarbeet tolerance; however, further research is needed to determine how complex mixtures affect weed, disease, and insect control, and whether environmental factors influence these outcomes.

221 - IR-4 Weed Science Update - Food Crops

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Residue projects

As of Nov 1, 2025, IR-4 data submitted to EPA led to over 110 new specialty crop uses in 2025. None of those were for weed science uses, unfortunately. IR-4 submitted three herbicide data petitions to EPA in 2025 (clomazone, Cycloate, and 2,4-DB). These submissions could potentially lead to approximately 90 new uses. Sixteen new herbicide and plant growth regulator (PGR) magnitude-of-residue studies began in 2025. They include bromoxynil burndown in canola, dry pea, and sunflower, flazasulfuron post-directed in hops, glufosinate post-directed in caneberries, glufosinate post-directed in sugarcane, linuron PRE in basil, dry beans, and succulent peas, orthosulfamuron in pomegranate, phenmedipham EPOST in spinach, pyridate in tomato row middles, and quinclorac post directed in cherry, peach and plum. Sixteen new herbicide and PGR residue studies are scheduled to begin in 2026. These include amicarbazone preplant/PRE in sweet corn, bicyclopyrone plus bromoxynil in grasses grown for seeds, clopyralid PRE in field pennycress, ethephon in pecan for uniform such split, flazasulfuron post-directed in cherry, peach and plum, halauxifen plus florasulam in hazelnut, maleic hydrazide foliar broadcast in tomatoes, metribuzin rotational interval reductions in lima bean and spinach, pyraflufen EPOST in bulb onion, pyroxasulfone in sesame, quizalofop in buckwheat, and topramezone burndown in dry pea and safflower.

Product Performance projects

Generating Product Performance (efficacy and crop safety) data to support registration of pest management tools in specialty crops continues to be an important part of the IR-4 annual research plan. The number of on-going herbicide Product Performance studies in 2025 was 29, including nearly 70 individual trials. The 2026 Performance research plan for herbicides and plant growth regulators includes fourteen continuing or new studies (nearly 30 individual trials).

Integrated Solutions projects

IR-4’s Integrated Solutions (IS) Program is structured to assist specialty crop growers outside of the traditional single product/single crop residue and product performance research. IS research efforts focus on crop-pest combinations to address solutions in these four areas, 1) pest problems without solutions, 2) resistance management, 3) products for organic production and 4) pesticide residue mitigation. In 2025, there were two active IS projects with herbicides and plant growth regulators (4 individual trials). Two new weed control IS studies were tentatively scheduled to begin in 2025 (~6 individual trials), including avocado and tame mustard, but recent restructuring of the IS program could mean that field trials will be delayed.

222 - Evaluation of Bromoxynil Mixtures Applied with Graminicides in Wheat

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Dichlorprop-p is a phenoxy herbicide being developed for use in small grains for the control of kochia (*Bassia scoparia*) and other broadleaf weeds. A premix herbicide with dichlorprop-p plus bromoxynil has been developed and submitted for registration for postemergence weed control in wheat and barley. Previous research has indicated that the active ingredient dichlorprop-p is compatible with grass herbicides and is less antagonistic than 2,4-D. Studies were conducted at 3 locations in North Dakota in 2025 to evaluate the effect of bromoxynil and bromoxynil premixes with dichlorprop-p or MCPA on the efficacy of the wheat graminicides, flucarbazone, thiencarbazone, and pinoxaden. When averaged across sites, formulations of bromoxynil plus MCPA or bromoxynil plus dichlorprop-p tank mixed with flucarbazone or pinoxaden did not reduce the efficacy on green foxtail and wild oats when compared to the graminicides alone. Similarly, wild oat control was not reduced by bromoxynil mixtures when tank mixed with thiencarbazone. These results indicate that the premix herbicide of dichlorprop-p and bromoxynil is compatible with grass herbicides commonly used in wheat.

223 - PPI, PRE, and POST Options for Common Ragweed Control in Dry Bean

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Common ragweed (*Ambrosia artemisiifolia* L.) has become increasingly difficult to control in dry bean (*Phaseolus vulgaris* L.) due to an elongated emergence time, limited post herbicides, and the occurrence of herbicide-resistant biotypes. This study was conducted to evaluate preplant incorporated (PPI), pre-emergence (PRE), and post crop emergence (POST) herbicides for common ragweed control at labeled

rates in dry bean. Three separate field experiments were conducted in randomized complete block design (RCBD) near Wolverton, MN. The PPI/PRE experiment treatments included EPTC, ethalfluralin, trifluralin, pendimethalin, *S*-metalochlor, dimethenamid-*P*, halosulfuron, and sulfentrazone & carfentrazone or their combinations. The POST experiment treatments included bentazon, fomesafen, halosulfuron, and imazamox or their combinations applied to 5-cm tall common ragweed. The PPI/PRE followed by (*fb*) POST experiment treatments included EPTC, ethalfluralin, halosulfuron, and sulfentrazone & carfentrazone or their combinations, *fb* single post application of fomesafen, bentazon, and halosulfuron or their combinations, when common ragweed reached 5 cm. Standard/non-treated check were included. Data on crop injury, weed control, biomass, and density were taken at 27, 35, 41, 44, and 58 days after planting (DAP). Data assumptions determined with Levene's test and ANOVA with *aov* procedure in *ARM*. Treatments means separated with Fisher's LSD. In the PPI/PRE experiment, no observed crop injury at 27 DAP or differences in weed densities at 44 DAP. EPTC in combination with PPI/RPE ethalfluralin, halosulfuron, and/or sulfentrazone & carfentrazone provided up to 81% control 27 DAP, comparable to the 80% control in the EPTC alone treatment. No treatments reduced common ragweed biomass compared to non-treated check. In the POST experiment, 47% was the highest weed control achieved 13 days after the first post application (DAFPA) with bentazon + halosulfuron + fomesafen at two application timings. At 22 DAFPA, no observed differences in weed densities across treatments. A 60-70% reduction in weed biomass compared to non-treated was observed in all treatments excluding the halosulfuron single application. In the PPI/PRE *fb* single POST experiment, weed biomass was reduced by 90-96% in all herbicide treatments compared to non-treated. Weed control was 63% in the EPTC + ethalfluralin [PPI] + sulfentrazone + carfentrazone [PRE] *fb* halosulfuron [POST], significantly lower compared to 76-90% control in all other herbicide treatments at 35 DAP. Similar trend observed at 41 DAP with 8-10% less weed control. At 57 DAP, weed control averaged 38-67% and comparable across herbicide treatments. At 58 DAP, no observed differences in weed densities. Crop injury averaged 10-27% and 5-20% at 35 and 41 DAP, respectively, with significant differences within herbicide treatments. Results suggest that no combinations of herbicides evaluated provided season-long control of common ragweed. These results reinforce that integrated weed control tactics will be required to control Group 2 + 14 resistant common ragweed in dry bean since herbicide programs did not provide sufficient control.

224 - Talinor: Earlier Applications for More Flexible Weed Control

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Talinor® is a selective herbicide from Syngenta Crop Protection containing bicyclopyrone + bromoxynil that has provided control of key broadleaf weeds in spring wheat, winter wheat, durum wheat, and barley since its 2017 U.S. launch. Pending EPA approval, an expansion of the current Talinor label will include preplant, preemergence, and early postemergence application timings (spike to 2-leaf). Applied at these earlier timings, the previously established rates of 213 to 283 g ai ha^{-1} can be effective for both burndown and soil-residual weed control while maintaining crop safety and yield potential. Data from US field trials demonstrated that preemergence applications of Talinor controlled broadleaf weeds including kochia (*Bassia scoparia*), Russian thistle (*Salsola tragus*), pigweeds (*Amaranthus* sp.), common lambsquarters

(*Chenopodium album*), and common ragweed (*Ambrosia artemisiifolia*) when sufficient incorporating rainfall was received. Additionally, these preemergence applications suppressed some annual grass weeds including foxtails (*Setaria* sp.) and barnyardgrass (*Echinochloa crus-galli*) with minimal crop response.

Herbicide Application Technology / Cover Crops & Integrated Weed Management

225 - Deposition Assessment of Asymmetric Fan Nozzles under Uniform and Alternate Arrangements

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Effective weed control depends on consistent droplet distribution that reaches multiple growing points along the stem, ensuring enhanced coverage and minimizing the potential for regrowth. Insufficient deposition can reduce herbicide efficacy and promote weed recovery. This study aimed to evaluate spray coverage patterns across multiple nozzle configurations, including fan orientations and asymmetric nozzles, to compare their performance with that of a conventional single-fan downward spray arrangement. Deposition patterns were tested on artificial collectors arranged within a custom-made frame that simulated obstacles. Frame enabled the evaluation of 360-degree spray exposure at 90-degree increments in vertical forms of exposure, like a stem. Spray applications were adjusted to a target volume of 140 L ha^{-1} and applied at two travel velocities (4.72 m s^{-1} and 2.36 m s^{-1}) for nozzle spacings of 38.1 cm (five nozzles) and 76.2 cm (three nozzles), respectively. Three nozzle types, AirMix, TD-ADF Standard (S), and TD-ADF Vario (V), were tested at 276 kPa. The TD-ADF S and TD ADF V nozzles were assessed in unidirectional spray patterns, followed by testing with alternate spray patterns (180-degree alterations). Spray deposition was evaluated using white paper (kromekote) collectors, 19.4 cm^2 treated with water and a food-grade blue dye solution (1.5 g L^{-1}). After card drying, cards were scanned at 31.5 dots mm^{-1}, and subsequently, the scans were analyzed using AccuStain 0.35 software. Additionally, all combinations tested here were evaluated in a low-speed wind tunnel to quantify droplet size. All nozzles produced very coarse sprays according to classification; however, droplet size followed a gradient: AirMix < TD-ADF S < TD-ADF V. There was no difference in top coverage among the nozzles (42.9 to 45.0%) and the nozzle spacing tested here. Despite adjustments in boom height and travel speed to maintain target volume for the two different nozzle spacings, the multidirectional spray deposition showed that the 38.1 cm spacing consistently provided superior coverage compared to the 76.2 cm spacing, with an increase of approximately 4-9%, depending on the target exposure. The only exception is the 180-degree assessment point, where no difference has been observed. The differences in spray deposition were observed on the front (0°) and back (180°) sides of the artificial collectors across examined combinations. The lateral target positions at 90° and 270° relative to the travel direction showed no differences across the examined nozzle configurations. These findings underscore the importance of a comprehensive understanding of how spray coverage impacts weed control efficacy, as well as the need for field trials to assess the influence of crop canopy on overall spray deposition and performance.

226 - Maximizing POST Herbicide Savings: The Role of PRE Herbicide Programs in Targeted Application Systems

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The use of preemergence (PRE) herbicides is critical for reducing early-season weed pressure thus increasing the efficacy of postemergence (POST) treatments by limiting weed density and size at the time of POST application(s). Novel targeted herbicide application technologies (THAT) have been reported to deliver POST weed control levels comparable to broadcast application while providing foliar herbicide savings. This Wisconsin research evaluated i) the impact of PRE herbicide selection on POST herbicide savings with THAT and ii) PRE fb POST strategies on season long weed control in corn and soybean production with broadcast vs THAT. Field experiments were conducted in 2025 at two Wisconsin locations: the UW Agricultural Research Station in Arlington (ARL) and O'Brian Farm near Brooklyn (BRO). Studies followed a 3×2×2 factorial design with three PRE levels (standard, strong, and none); two POST application methods (broadcast vs. targeted); and inclusion of a layered residual herbicide at POST (yes and no). Applications were made using the One Smart Spray small-plot research sprayer prototype calibrated to deliver 140 L ha^{-1}. The standard PRE consisted of Boundary (S-metolachlor + metribuzin) in soybean and Dual II Magnum (S-metolachlor) + Princep (simazine) in corn. The robust PRE program included Tendovo (S-metolachlor + metribuzin + cloransulam-methyl) in soybean and Storen (S-metolachlor + mesotrione + pyroxasulfone + bicyclopyrone) + Princep in corn. All POST treatments included Roundup Powermax 3 (glyphosate), Liberty (glufosinate), and Enlist One (2,4-D) in soybean and Status (diflufenzopyr + dicamba) + Roundup Powermax 3 in corn, with or without a layered residual herbicide (Dual II Magnum). In corn, a strong PRE program reduced POST herbicide use by 70% at ARL and 61% at BRO, compared with 5% and 35% savings for standard PRE, and only 2 and 3% for no PRE. In soybean, high grass pressure and limited rainfall at ARL resulted in lower POST herbicide savings, where strong PRE provided 5% savings compared to 4% with standard PRE and 1% with no PRE. At BRO, under high waterhemp pressure, strong PRE provided 28% savings, compared to 5% and 3% for standard and no PRE, respectively. Robust PRE programs achieved the greatest weed control at the time of POST application, while the inclusion of residual herbicides in POST programs further improved weed control by 4% at ARL and 6% at BRO in soybean, for both targeted and broadcast applications 14 days after treatment (DAT). Similar trends were observed in corn, where adding residual herbicides POST improved weed control by 7% at ARL and 11% at BRO 14 DAT. These findings highlight the importance of robust PRE programs in maximizing the performance of THAT. From a weed control, resistance management, and herbicide savings standpoint, strong PRE programs reduce early-season weed pressure, allowing targeted systems to treat a smaller portion of the field, lower selection pressure on POST herbicides, and decrease overall POST herbicide use. This is especially valuable for managing Amaranthus spp., where POST options are limited, and maintaining their effectiveness over time is critical for sustainable weed management.

227 - Isolation of Heat Tolerant Phosphate Solubilizing Rhizobacteria and their Role in Enhancing Cotton Growth and Nutrient Uptake in Calcareous Soils

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Heat stress in phosphorus-deficient calcareous soils is a major constraint to cotton productivity in arid regions, and its severity is expected to increase under climate change. Utilizing the potential of heat-tolerant phosphorus solubilizing bacteria (PSB) in the cotton rhizosphere offers a sustainable biofertilizer solution, however, their diversity, functional capacity, and agronomic potential remain poorly understood. The current study aimed to isolate heat-tolerant PSB from the cotton rhizosphere, characterize them and test their effect on cotton plant growth. The results showed that phosphate solubilization efficiency of isolated strains on National Botanical Research Institute’s Phosphate (NBRIP) agar and liquid media varied from 22.5 to 134.5% and 594 to 2623%, respectively. Efficient bacterial growth (0.130 to 1.459 OD) was recorded at 40°C, moderate (0.133 to 0.951 OD) at 45°C, and slowly (0.068 to 0.332 OD) at 50°C. The isolates TPB4, TPB19, and TPB30 improved cotton growth for all recorded parameters in the pot experiment, whether used alone or in all combinations, compared to uninoculated control. With the combined use of TPB4, TPB19, and TPB30 as consortia indicated the highest increase in shoot length (29%), root length (30%), shoot fresh weight (37%), shoot dry weight (41%), root fresh weight (68%), root dry weight (81%), photosynthetic rate (35%), transpiration rate (23%) and chlorophyll content (30%). PSB inoculation elevated shoot N, P, and K concentrations; increased soil N and K; enhanced phosphatase activity (up to 169.3 µg PNP g^{-1} h^{-1}) and PSB population; and lowered soil pH from 8.25 to 7.35. Soil P fractionation revealed substantial increases in Olsen-P and Ca_2-P, with concurrent declines in Ca_8-P, indicating transformation of less-available P pools into plant-available forms. These findings highlight the potential of multi-strain thermo-tolerant PSB consortia as climate-resilient biofertilizers to sustain cotton yields in P-limited arid regions.

228 - Overlapping Residual Programs in Early Planted Soybean

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The overlapping residual herbicide approach to weed management involves applying a full rate of soil residual herbicides at the PRE timing, followed by a POST application of additional residual herbicides before the first flush of weed emergence. This strategy provides additional residual control before the complete degradation of the residual herbicides applied at the PRE timing. Overlapping soil residual herbicides may reduce selection pressure for herbicide resistance to foliar-active herbicides. Field experiments were conducted in 2024 and 2025 at three locations in Indiana [Pinney Purdue Agricultural Center (PPAC), Throckmorton Purdue Agricultural Center (TPAC), and Meigs] representing different soil properties and weed spectrums. Experimental objectives were to: (1) Evaluate the effect of including soil residual herbicide application at the early POST timing (V3 soybean growth stage), before weed

emergence, on the weed density at POST application containing only foliar-active herbicides; and (2) Assess the effect of soybean planting timing and overlapping soil residual herbicide program on weed control and soybean yield. The experimental design was a two-by-seven factorial arrangement. Factor A was soybean planting date, with two levels: early and late planting. Factor B consisted of six herbicide programs plus a nontreated control. The experiment was arranged in a split-plot design with four replications. Planting date was the whole-plot factor with herbicide program as the subplot factor randomized within each main plot. Soybean cultivars were resistant to 2,4-D, glufosinate, and glyphosate. Data collection included weed counts (plants m^{-2}) of predominant weed species at the POST herbicide application timing of foliar-active herbicides Predominant weed species at the sites included waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer], giant ragweed (*Ambrosia trifida* L.), and common lambsquarters (*Chenopodium album* L.). Soybean stand counts were recorded at the V3 growth stage, and grain yield was estimated at physiological maturity. Additional weed density and biomass data were collected at soybean harvest. Early planting increased soybean stand counts compared to late planting but did not consistently increase yield across site-years. Early planting resulted in increased common lambsquarters and giant ragweed density at the POST application compared to late planting, while the opposite trend was observed for waterhemp. The overlapping residual herbicide program did not reduce waterhemp, giant ragweed, or common lambsquarters density at POST compared to the PRE fb. POST program but reduced giant ragweed and waterhemp biomass at soybean harvest. Results suggest that the benefits of overlapping residual herbicide programs for herbicide resistance management compared to PRE fb. POST programs are year-dependent. Future research should investigate the effect of different application timings of overlapping residuals on weed density at the POST application of foliar-active herbicides.

229 - Flame Weeding in Soybean: Crop Tolerance Confirmed During Flowering Stage

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Propane flame weeding is commonly used for weed control in organic soybean production during vegetative growth stages. However, the extended emergence period of weeds often necessitates additional management during reproductive stages. This study evaluated soybean response to flame weeding at vegetative (V4) and reproductive (R1 and R2) growth stages, using two torch heights (15 and 23 cm above ground) and five propane doses (0, 28, 37, 47, and 59 kg ha^{-1}), and to assess their effects on soybean growth and yield. Field experiments were conducted in 2022 and 2023 at the University of Nebraska-Lincoln Eastern Nebraska Research, Extension, and Education Center (ENREEC). The highest crop injury (up to 90%) occurred at 7 days after treatment (DAT) when flaming was conducted at the V4 stage, compared with 40 to 50% injury observed at flowering stages. Despite initial injury, plants recovered substantially by 28 DAT, regardless of flaming stage. Yield components, including pods per plant (41-54), seeds per pod (2.4-2.6), and hundred-seed weight (11.3-13.7 g), as well as grain yield did not differ significantly across propane doses, torch heights, or growth stages ($0.219 < p < 0.948$). These findings suggest that propane flaming performed during soybean flowering stages, can be safely integrated into organic weed management programs without compromising yield.

230 - Influence of Long-term Cover Crop on Weed Density and Seedbank Communities in Soybean-Corn Cropping Systems in Iowa

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Cover crops have traditionally been adopted to improve soil health and promote agroecosystem sustainability. More recently, their potential as a weed management tool has gained increasing attention. By competing for resources, cover crops can suppress weed emergence and growth, and their consistent use over time may reduce the size of the soil seedbank. This study aimed to evaluate the aboveground weed communities and seedbank in long-term cereal rye (*Secale cereale*) cover-crop and non-cover-crop areas within soybean-corn (*Glycine max-Zea mays*) cropping systems across Iowa. Field experiments were conducted at eight locations throughout the state, where cereal rye fields were planted following soybean or corn harvest in 2024 and terminated prior to corn or soybean planting in 2025. Soil samples were collected at 2-4 weeks after crop planting, and weed density counts at the same timing and again at 5-7 weeks after crop planting. The experiments followed a complete block design with two treatments (cover crop and non-cover crop) and three or four replications per site. Within each replication, soil and weed samples were collected from five randomly selected points. Soil samples were transported to the laboratory and stored in a freezer until processing. Samples were then processed through elutriation, flotation, and air separation to isolate organic material and seeds from the mineral soil fraction and facilitate seed identification and counting. Weed densities were assessed using a 0.25 m^2 quadrat. Data analysis were conducted in SAS software using PROC GLIMMIX procedure and means were separated using Tukey's test at alpha=0.05. Across sites, the average waterhemp (*Amaranthus tuberculatus*) density and seed count in non-cover-crop was 1.6 plants m^{-2} and 12951 seeds m^{-3}, respectively, compared to 0.5 plants m^{-2} and 9039 seeds m^{-3} in cover-crop. However, these differences between treatments were not significant. Although seed densities and counts tended to be lower in cover-crop areas, variability among sites may have masked treatment effects, indicating that further investigation is needed to evaluate the cumulative effects of cover cropping on weed communities and seedbank depletion over time.

231 - Temperature Effects on Postemergence Herbicide Efficacy for Controlling Large Crabgrass (*Digitaria sanguinalis*) in Ornamental Production

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Elevated temperatures can intensify weed issues by accelerating weed growth and germination, especially for C_4 species, due to their heat tolerance and efficient carbon fixations, making their control more challenging. Temperature also influences herbicide absorption, translocation, and metabolism. Large crabgrass (*Digitaria sanguinalis* L.), a highly problematic C_4 weed, poses a significant threat to nursery and field-grown ornamentals under these conditions. This study aims to evaluate the efficacy of postemergence herbicides at different rates (0.5X, 1X, 2X) under ambient and elevated temperatures for managing large crabgrass in ornamental production. Experiments were conducted in summer and fall

2024 using a growth chamber and an open hoop house setup. Large crabgrass seeds were sown in pots filled with standard substrate, irrigated, and placed in separate growth chambers where temperatures were maintained at ambient (22-28°C) and at 2-5°C above the species' optimum range (28-34°C). Once weeds reached the 3-6 leaf stage, they were transferred to an open hoop house for herbicide application. Postemergence herbicides such as topramezone and glyphosate were applied at 0.5X, 1X, and 2X rates using a CO_2 backpack sprayer. After the restricted entry interval, treated weeds were placed back to their respective growth chambers and maintained there for four weeks. A control treatment without herbicide application was maintained in both growth chambers. Weed control ratings were visually assessed at 1, 2, 3, and 4 weeks after treatment (WAT) using a 0-10 scale, where 0 = no control (green foliage, upright growth, no damage) and 10 = complete plant death (dark brown foliage, no green tissue, collapsed structure)). At 4 WAT, all weeds were harvested, and dry weight of aboveground parts of weed was recorded. The experiment followed a completely randomized design with eight replications per treatment and was repeated twice. Data were analyzed using ANOVA in SAS 9.4, and treatment means were separated using Fisher's LSD test. The results showed that at 4 WAT glyphosate weed control efficacy at ambient temperature was 88% which reduced to 73% under elevated temperature condition. Whereas the high temperature increased topramezone efficacy by 10% relative to ambient temperature. The lowest amount of weed dry weight was observed at 2X rates in high temperature conditions, but no difference was observed among rates at ambient temperature. Hence it can be concluded that with an increase in temperature, higher rates of the tested herbicides will be required for effective weed management in ornamentals.

232 - Cereal Rye Cover Crop for Weed Suppression in Corn-Soybean Systems: Wisconsin Research Lessons

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Cereal rye (*Secale cereale* L.) is increasingly adopted across the U.S. Midwest as part of integrated weed management (IWM) systems aimed at reducing exclusive reliance on herbicides and improving sustainability. Our multi-year research program has examined the role of cereal rye biomass accumulation, termination timing, and interactions with soil residual herbicides in weed suppression and soybean (*Glycine max* [L.] Merr.) development and yield. Results from field trials conducted in Wisconsin and across the North Central region demonstrated that high cereal rye biomass (>4-5 Mg ha^{-1}) effectively reduced early-season emergence and growth of troublesome weeds such as waterhemp (*Amaranthus tuberculatus* [Moq.] Sauer) and giant ragweed (*Ambrosia trifida* L.) by over 50%. Studies integrating early-planted soybean in planting-green systems showed that delaying cereal rye termination until soybean emergence optimized biomass production and *Amaranthus* spp. suppression without compromising yield, particularly when combined with an effective soil residual herbicide. Additional research revealed that while cereal rye biomass intercepts a portion of preemergence herbicide spray, early-season residual control was not negatively affected. Over a five-year period, continuous cereal rye

adoption improved soil carbon, organic matter, and aggregate stability, further supporting its role in sustainable production systems. Collectively, this body of work demonstrates that successful integration of cereal rye into IWM programs requires managing for sufficient biomass accumulation to achieve meaningful weed suppression while maintaining compatibility with herbicide programs and protecting crop yield.

233 - Wisconsin Insights from 2025 Research on Targeted Herbicide Application Technologies

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Advancements in targeted herbicide application technologies are reshaping chemical weed control strategies. A series of field studies conducted in Wisconsin from 2022 to 2025 evaluated the advantages and limitations of targeted spray systems in corn (*Zea mays* L.) and soybean (*Glycine max* (L.) Merr.) production. Research included simulated targeted herbicide applications, field evaluations using the One Smart Spray system, large-scale field trials with a commercial John Deere See & Spray™ Premium system operating on 120-ft boom across more than 2,500 acres of cropland, and the Ecorobotix ARA UHP™ system assessed in non-GMO corn-soybean cropping systems. These systems function as dynamic, sensor-driven platforms that may produce variable spray quality compared to conventional broadcast applications. Results demonstrated that agronomic fundamentals, such as proper nozzle selection and droplet size, boom height, system calibration, and wind speed during applications remain critical to successful outcomes and strongly influenced weed detection and weed control effectiveness. Targeted herbicide applications effectively reduced herbicide input, particularly under conditions of low weed density and uniform early-season crop canopy development. However, some in-row weeds and small weeds between rows were not detected and controlled, highlighting what needs to be improved in detection accuracy. Herbicide savings were greatest under low weed pressure scenarios. Moreover, under high herbicide savings, reduced downwind spray particle drift was quantified when compared to broadcast applications. Beyond herbicide savings, targeted application technologies present opportunities for integrated weed management. The ability to collect georeferenced weed detection data provides a foundation for site-specific crop monitoring and weed mapping, offering new pathways for adaptive management and long-term resistance mitigation. As these technologies evolve, they may serve not only as tools for input efficiency but also as catalysts for rethinking herbicide stewardship within sustainable production systems. Overall, three-year research in Wisconsin underscores that while sensing technologies hold promise for improving efficiency and sustainability, the fundamentals of agronomy and weed science remain the foundation of success. Integrated weed management strategies will continue to be essential as precision systems become more prevalent in modern crop production.

234 - The Utility of Glufosinate for Weed Management in the Central Great Plains

Philip Westra[1]

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Abstract not available.

Society Breakfast, Student Contest Awards & What's New in Industry S*ymposium*

234 - Keynote Address

Corey Guza*

Michigan Sugar Company, Bay City, MI

Abstract not available.

235 - Industry Updates

Sustaining Member Company representatives*

Abstract not available.

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