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NCWSS

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The abstracts of posters and papers presented at the annual meeting of the North Central Weed Science Society are included in this proceedings document. Titles are grouped in the program by subject matter with the abstract number listed in parentheses.

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Women in Weed Science Breakfast

Highlighting Your Worth: Ideas for Negotiating (1)

No abstract submitted.

Poster Section - Cover Crops and Integrated Weed Management

Integrated Weed Management Using Cereal Rye Residue in No-till Soybean (2)

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Integrated Weed Management (IWM) is essential for mitigating herbicide-resistant weed populations and reducing reliance on post-emergence herbicides in no-till crop production. One potential IWM strategy is combining terminated cereal rye cover crop (*Secale cereale* L.) residue with pre-emergence herbicides. Upon termination, cereal rye residue creates unfavorable conditions for weed seed germination and seedling emergence, effectively suppressing small-seeded broadleaf weeds, although larger-seeded broadleaf, annual grass, and perennial species are less affected. This study evaluated how varying cereal rye biomass levels and their interaction with a pre-emergence herbicide affected small-seeded smooth pigweed (*Amaranthus hybridus* L.) and large-seeded giant ragweed (*Ambrosia trifida* L.) densities in no-till soybean. To generate varying biomass levels, two field trials were conducted with different rye planting dates (October vs. November) and two termination timings. Early termination occurred six weeks prior to planting, while late termination, known as the "planting green" approach, terminated cereal rye at soybean planting. The experiment uses a randomized split-plot block design with termination timings (including no cover crop control) as main plot factors, while pre-emergence treatment (chlorimuron [21 g ai ha^{-1}] + flumioxazin [77 g ai ha^{-1}] + pyroxasulfone [98 g ai ha^{-1}] and no-herbicide control) was the split-plot factor. In both trials, "planting green" increased rye biomass compared to early termination, with October-planted rye yielding 12,434 kg ha^{-1} versus 3,434 kg ha^{-1}, and November-planted rye yielding 2,702 kg ha^{-1} versus 171 kg ha^{-1}. Weed counts in predetermined sampling areas (2 m^2) were conducted at the first post-emergence herbicide timing. In the October-planted trial, ANOVA results showed a significant interaction between rye termination timing and pre-emergence herbicide application on smooth pigweed density ($p = 0.004$). Without the pre-emergence herbicide, "planting green" reduced smooth pigweed density compared to the control and early termination treatments. However, with the herbicide, smooth pigweed density remained low across all treatments, with no significant differences. Giant ragweed density was unaffected by treatments. In the November-planted trial, ANOVA indicated no significant interaction between termination timing and pre-emergence herbicide on either species. Moreover, significant effects of the pre-emergence herbicide were observed on smooth pigweed ($p = 0.004$) and giant ragweed ($p = 0.01$) densities, while the absence of main plot treatment effect may be attributed to lower rye biomass production in this trial. In the October-planted trial, cover crop treatment affected soybean yield ($p = 0.03$), with "planting green" significantly reducing

average yield to 469 kg/ha compared to 592 kg ha^{-1} for early termination and 654 kg ha^{-1} for the control. The November-planted trial showed no significant differences in average yield across treatments, with control, early, and late termination averaging 594 kg ha^{-1}, 542 kg ha^{-1}, and 578 kg ha^{-1}. The density results from the first post-emergence herbicide timing demonstrate that high residue from late terminated, October-planted rye can provide effective early-season smooth pigweed suppression, similar to pre-emergence herbicide. However, such high residue level may also contribute to reduced soybean yield, as observed in the same trial. Therefore, future studies are needed to balance weed suppression benefits while achieving optimal soybean yield.

The Impact of Cover Crops on the Weed Seed Bank of Nebraska Row-Crop Systems (3)

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Cover crop use is a well-known practice among Nebraska farmers, offering many benefits including erosion management, decreased soil compaction, nutrient cycling, and weed suppression. Cover crop biomass production is highly correlated with these cover crop benefits. Due to the short growing season following crop harvest, cover crops can be interseeded prior to harvest in corn and soybeans to increase cover crop biomass. Herbicide resistance has resulted in reduced weed control, leading farmers to look for new strategies to control weeds while keeping their farm profitable. Use of cover crops as a weed suppression tool is a strategy that warrents futher investigation. The objective of this study was to evaluate the impact of cover crops on the weed seed bank in row-crop systems in Nebraska. Seven fields across Nebraska were soil sampled using hand probes, and collecting the first 12.7 cm of topsoil to assess the weed seed bank following different cover cropping. The fields are located in Mead, Wahoo, York, Columbus, Utica and Brule (NE). These fields were selected based on cover cropping for the past two to fiver years where cover crop species such as Cereal rye (*Secale cereale* L.*)*, Rapeseed (*Brassica napus* L.), Turnip (*Brassica rapa* L.*)* and Winter wheat (*Triticum aestivum* L) were mainly seeded late season or after harvest. The on-farm fields are part of the Highboy Cover Crop study, which includes treatments with and without cover crops. A greenhouse bioassay was conducted to evaluate the weed seed bank. Soil samples taken were incubated in a greenhouse with settings to mimic field conditions such as temperature, light and moisture. Soil samples were evenly distributed in plastic pots 103 cm^2 . Data collection was done every seven days after emergence and included emergence rate of the seedlings, plant height counting, weed species identification and aboveground biomass at 28 days after emergence.

Weed and Crop Management Strategies: Practical Insights from a Wisconsin Systems Study (4)

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Farmers across the North Central region producing corn and soybean grain crops are increasingly interested in including a cover crop in their rotation. Including a cover crop in a rotation requires changes to tillage regime, equipment modifications and upgrades, considering cover crop termination timing, and the overall effect on profitability. Since 2018, a team of University of Wisconsin-Madison researchers have partnered to compare the effects of tillage and cover crop termination timing in a corn and soybean systems-based study in combination with preemergence herbicides. This study was developed to help farmers make decisions regarding reducing crop tillage passes and incorporating a cover crop. These studies are located at the Lancaster and Arlington Agricultural Research Stations in Southern Wisconsin. The study treatments include the following six soil management practices with or without the use of a preemergence herbicide: tillage, no-till, cereal rye (*Secale cereale* L.) terminated two weeks prior to grain crop establishment, planting green and cereal rye terminated day of crop establishment, planting green and cereal rye terminated two weeks post grain crop establishment, and cereal rye harvested for forage and then grain crop establishment. At each trial site, there are two studies where the rotation phases are alternated between the same two fields, thus corn and soybean crops are present at each location every year. Crop yield and weed data have been collected to help provide farmers, agronomists, and researchers many points to consider when adopting these cropping systems changes but do not fully explain what agronomic management changes are necessary. The practical agronomic insights learned from this complex trial are critical for farmer practice adoption and success. These insights include planter maintenance and modifications, crop hybrid and variety maturity ratings for corn, soybean, and cereal rye, and soil fertility application rates and timings. To ensure proper grain crop establishment, the planters used for this study were evaluated for routine maintenance needs and repairs completed, and upgrades were made to add a spiked closing wheel to close the seed furrow in a high residue environment. Corn hybrid, soybean and cereal rye varieties were selected for early maturity to allow for early fall cover crop establishment and early spring cereal rye biomass accumulation. Soil fertility levels were measured using routine soil sample data analysis and fertility levels were adjusted to University of Wisconsin-Madison recommendations for a corn-soybean crop rotation. Additionally, corn nitrogen applications were split-applied using urea at rates of 44.8 kg ha^{-1} at planting and 134.4 kg ha^{-1} broadcast at the V4-V6 corn growth stage. The trial has demonstrated limited treatment effects on soybean yield but some major reductions in corn yield with high biomass cover crop. Crop yields, soil management changes, and agronomic management changes all have a significant impact on the overall profitability of this system. The economics will be calculated for each treatment of this study and the study continues for the 2025 crop year. The practical insights gained from these trials should be shared with farmers interested in adopting any of the conservation practices studied.

Impact of Fall-Planted Cover Crop and Tillage on Weed Control and Soybean Yield (5)

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With the rapid evolution and spread of herbicide-resistant weeds, it is critical to consider integrated weed management strategies, which combine both chemical and non-chemical tactics. A field study was conducted in 2024 at the University of Minnesota's Northwest Research and Outreach Center near Crookston, MN, to compare cultural (cover crop) and mechanical (tillage) weed management practices combined with herbicide treatments for controlling common ragweed (*Ambrosia artemisiifolia* L.), and their effects on soybean [*Glycine max* (L.) Merr.] yield. The treatments were arranged in a split-plot design with four replications. The main plot factors included tillage and cover crop (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 42 days after planting, the combination of 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}. The highest soybean yield (3,750 kg ha^{-1}) was achieved when conventional tillage combined with the PRE treatment. Overall, treatments that included PRE herbicides showed a better control of common ragweed and higher soybean yield compared to burndown and no herbicide.

Evaluating Allelopathic Effect of Barley (*Hordeum vulgare*) on Palmer Amaranth (*Amaranthus palmeri*) (6)

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Palmer amaranth (*Amaranthus palmeri* S. Watson) is a fast-growing, herbicide-resistant weed that poses a serious threat to agriculture. Studies have shown that Palmer amaranth can cause yield losses in soybean of up to 64% with an infestation density of only 3.33 plants $meter^{-1}$, while corn yield reductions can reach as high as 91%. Integrating allelopathic crops, such as barley (*Hordeum vulgare* L.), into crop rotations could contribute to weed suppression in the following crop through the breakdown of residues. This study provides a baseline and seeks to quantify the suppressive ability of root exudates from living barley plants on Palmer amaranth seedling growth, comparing this to cereal rye (*Secale cereale* L.), a known allelopathic cover crop. Additionally, the role of competition in modulating the production of allelopathic compounds was investigated. The experiment employed a modified plant box method with five treatments: (1) barley cv. 'Violet'; (2) cereal rye; (3) barley previously grown with Palmer amaranth; (4) cereal rye previously grown with Palmer amaranth; and (5) a control (no allelopathic donor). After 20 days of growth, donor plants were transplanted into root zone-separating tubes, which were then placed into 7.6x7.6x10 cm polycarbonate boxes filled with 0.75% agar and 1% sucrose. Thirty Palmer amaranth seeds were sown on the agar surface at set distances from the barley root zone. Boxes were wrapped in light-excluding tape at the agar level and incubated at 24 °C with a 14/10 light/dark photoperiod for five days. Data were analyzed using linear regression, plotting root and shoot length relative to the distance from the barley root zone. Results indicated that Palmer amaranth root and shoot growth was significantly affected by barley and cereal rye root exudates in all treatments (p <

0.01). Growth inhibition (GI; %) was calculated using the formula: GI = 100 - (treatment intercept/control intercept) * 100. Barley root exudates were found to inhibit Palmer amaranth root growth by 45.5% (R^2 = 0.49) and shoot growth by 31% (R^2 = 0.30), while cereal rye reduced root growth by 31% (R^2 = 0.49) and shoot growth by 14.8% (R^2 = 0.27). Additionally, barley previously exposed to Palmer amaranth reduced root growth by 58.9% (R^2 = 0.55) and shoot growth by 37.4% (R^2 = 0.26). Cereal rye previously exposed to Palmer amaranth reduced root and shoot growth by 39.6% (R^2 = 0.27) and 38.2% (R^2 = 0.23), respectively. These findings suggest that root exudates from barley and cereal rye inhibit Palmer amaranth growth within five days of interaction, with prior exposure to Palmer amaranth enhancing the suppressive effect. This and other studies in a controlled setting will serve as a basis to assess the impact of allelochemicals in field studies to examine their efficacy in an applied management context as a tool in integrated weed management.

Viability of Weed Seed Following Electrocution Treatment (8)

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One method of late-season weed control used in some row-cropping systems is electrocution, often referred to as “weed zapping”. This method is becoming increasingly popular in Ohio, especially among organic soybean (*Glycine max* (L.) Merr.) producers. A study was initiated to learn more about the efficacy of electrocution for killing weed seeds and/or preventing weed seeds from maturing and reducing viability of seeds from treated plants. Velvetleaf (*Abutilon theophrasti* Medik.) seed was collected from organic soybean fields that had been treated with electrocution across four locations in Northwest Ohio, namely: Wauseon, Napoleon, Deshler, and Leipsic (Fulton, Henry, and Putnam counties). From each field, seed was collected from both treated (zapped) and untreated (not zapped) plants. After collection, seed was cleaned with metal sieves and placed into plastic bags and placed in cold storage (4°C). To determine viability, a germination test was conducted on the velvetleaf to compare treatment effects (zapped vs unzapped). This study was replicated three times for a total of 24 experimental units. Fifty seeds were placed in each petri dish, with damp blotter paper below and on top of the seeds. These were placed into a growth chamber (25°C) for seven days. Following seven days in the growth chamber, germinated seeds were counted, and percent germination was recorded. At this evaluation timing, 13% of the untreated seeds had germinated relative to 11% of the treated (zapped) seeds, averaged across location. There was no statistical difference between these two values. These data suggest that there may not be a difference in seed viability from electrocution treatments, which could be dependent on treatment timing, species, and maturity at treatment. More research regarding weed seed viability following electrocution studies should be done to further elucidate the effects of electrocution treatments. Evaluating more species and a greater number of populations would be beneficial for Ohio growers.

Electrocution as a Late Season Weed Control Tool: A Multi-State Study (10)

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While herbicide applications are the primary method of controlling weeds in U.S. soybean production systems, managing herbicide-resistant and/or late-emerging weed escapes may require alternative approaches. Implements that use electricity to kill weeds, like the Weed Zapper™, are becoming increasingly popular among organic and specialty crops producers. A field trial was conducted in 2021 and 2022 in seven locations across the Midwestern US (Illinois, Indiana, Iowa, Kansas, Nebraska, and Missouri) to evaluate weed electrocution as a method of controlling late-season weed escapes in soybeans. Treatment structure varied across site-years, but all trials included electrocution at two speeds (4.8 and 8.1 km h^{-1}) and at least one comparison rescue treatment (e.g., inter-row cultivation, inter-row mowing or rope-wick herbicide application). The weed species evaluated differed from site to site but included waterhemp (*Amaranthus tuberculatus*), Palmer amaranth (*A. palmeri*), common lambsquarters (*Chenopodium album*), velvetleaf (*Abutilon theophrasti*), giant ragweed (*Ambrosia trifida*) and giant foxtail (*Setaria faberi*). The soybean stage at which treatment occurred ranged from R1 to R6. Weed control was visually assessed at three timings: 7 and 14 days after treatment, and at soybean maturity, and soybean and weed heights were also measured. Averaged across sites, years and species, weed control was not affected by electrocution speed. In general, electrocution provided the highest control of giant ragweed (87%) and worst control of velvetleaf (10%). Higher differences between crop and weed heights tended to positively influence weed control provided by electrocution. In 2021, weed seeds present on the soil surface after harvest were counted, and data suggest that electrocution may reduce deposition of Amaranthus spp. seeds by up to 30%. These results highlight the potential use of electrocution, along with other non-chemical methods, as alternative late-season weed control methods in soybean.

The Influence of Biological Residue Management Products on the Viability of Cover Crop and Weed Seed (11)

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Biological treatments are increasing in popularity as growers seek to maximize crop yields. One type of biological known as “residue management” products are applied to reduce crop residue by breaking down corn stalk exteriors and increasing microbial breakdown. These products also claim a reduced germination potential of volunteer corn left on the soil surface. This study explores the effects of this biological product on the germination and early growth of ten plant species. These species consist of five cover crops [cereal rye (*Secale cereale* L.), hairy vetch (*Vicia villosa* Roth), winter peas (*Pisum sativum* subsp. arvense), crimson clover (*Trifolium incarnatum* L.), and wheat (*Triticum aestivum* L.)] and five commonly occurring weed species [giant ragweed (*Ambrosia trifida* L.), velvetleaf (*Abutilon theophrasti* Medik.), common lambsquarters (*Chenopodium album* L.), waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer), and giant foxtail (*Setaria faberi*

Herrm.)]. These plants were selected to examine the potential for these biological treatments to potentially reduce weed density in integrated weed management systems and forecast potential issues with germination of broadcast seeded cover crops. A randomized complete block design (RCBD) trial was implemented, with two factors under consideration: 1) plant species, and 2) the presence or absence of a biological treatment. Each of the 10 species were planted in individual pots. The biological treatment (*Bacillus* spp.) was applied at the labeled rate of 1.17 L/ha rate with a single-nozzle track spray chamber set to apply 140 L ha^{-1} with a flat spray tip (8001EVS). The experiment was replicated three times, resulting in a total of 60 experimental units. The germination rate will be measured weekly for four weeks to assess the influence of the biological treatment on the germination and growth of the cover crop and weed species. Preliminary findings from the germination evaluation 7 days after treatment (DAT) reveal that an average of 2.8 seeds treated with the biological germinated as compared to 1.7 seeds that were not treated with the germinated, averaged across species, and that these values were not statistically different. Further evaluation at 14, 21, and 28 DAT will provide more insight into the influence of this biological residue management product on seed germination. These results will lead to a better understanding of biological treatments effects and whether they may enhance or decrease the germination of certain plants, which may or may not be species specific. Future work should evaluate different residue management products as well as different rates, application timings, watering schemes and timings, and additional species.

PRE Herbicides Bioassay: Impact of Cereal Rye Cover Crop on Residual Weed Control (12)

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Herbicide-resistant weeds are one of the biggest challenges for farmers in the US Midwest, with an increasing number of troublesome species developing resistance to multiple herbicide modes of action. Recent research on integrated weed management highlights pre-emergence (PRE) herbicides and cover crops as a combined strategy to control and minimize the occurrence of resistant weeds. However, the cover crop biomass can act as a physical barrier when PREs are applied, interfering with residual weed control. A greenhouse bioassay with samples collected from a field study was conducted to assess the impact of cereal rye cover crop (CC) on the efficacy of PREs over time, compared to no-till (NT) without CC. The field study was conducted in 2024 at Arlington, WI using a RCDB with a split-plot design with the main plot being herbicide treatments and subplots the CC or no-till management. Herbicide treatments consisted of metribuzin (315 g ai ha^{-1}), flumioxazin (70 g ai ha^{-1}), pyroxasulfone (109.6 g ai ha^{-1}), flumioxazin + pyroxasulfone (89 g ai ha^{-1}), and metribuzin + flumioxazin + pyroxasulfone (89 g ai ha^{-1}). Glyphosate at 1261 g ae ha^{-1} was applied with the PRE treatments to terminate the CC and control established weeds. Cereal rye was 78 cm tall and had 5,700 kg $ha\text{-}^{1}$ at termination and PRE application. A 20 mm rainfall occurred within 24 hours after PRE application. Treated soil was collected from a depth of 0 - 7.6 cm on three dates after application (DAA): 0, 21 and 42. Subsequently, two greenhouse bioassay runs in a complete randomized design were conducted using waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] as a bioindicator species. Individual pots were filled with field treated soil and seeded with a fixed volume of 200 seeds. At 28 days after establishment, plants were clipped at the soil level and dried at 60°C until constant weight. The biomass results showed that at 0 DAA, only metribuzin and flumioxazin had lower waterhemp biomass reduction under CC (68% and 91%, respectively) when compared to NT (96% and 97%). At 21 DAA, only flumioxazin showed lower waterhemp biomass reduction under CC compared to NT (11% to 39%), opposed to the treatments of metribuzin and flumioxazin + pyroxasulfone, which had higher biomass reduction under CC. Flumioxazin, flumioxazin + pyroxasulfone, and metribuzin + flumioxazin + pyroxasulfone all had higher biomass reduction at 42 DAA under the CC system compared to NT (46 vs 8%, 43 vs 10%, and 69 vs 35%, respectively). No difference between CC and NT was observed for pyroxasulfone only treatments ($P>0.05$). The findings of this bioassay do not support the initial hypothesis of reduced residual weed control over time because of CC interception, as no consistent decrease in residual activity was observed across treatments with cereal rye cover crop, which could be partly explained by the precipitation following application. Further investigation on how specific residual herbicides behave when sprayed over cover crop biomass compared to no-till can support the development of better integrated weed management strategies.

Soybean Tolerance to Flaming During Flowering Stage (13)

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Propane flame weeding is commonly used in soybean during vegetative stages. However, due to the extended emergence period of weeds and possible weather constraints, weed control may also be necessary during the reproductive stages. This study aimed to assess the effects of flame weeding on soybean growth and yield at both vegetative (V4) and reproductive (R1 and R2) stages, at different torch heights (15 or 23 cm from the ground) and propane rates (0, 28, 37, 47, and 59 kg ha^{-1}). Field studies were conducted in 2022 and 2023 at the University of Nebraska-Lincoln Eastern Nebraska Research, Extension, and Education Center (ENREEC). Soybean visual injury was evaluated at 7 and 28 days after treatment (DAT). Crop was hand harvested at physiological maturity. Regression analysis were conducted in R software environment, using stat and drc packages. The highest soybean visual injury (90%) occurred when flaming was performed at the V4 stage 7 days DAT, compared to 40-50% injury when conducted at flowering stages. Despite high initial injury, substantial recovery was observed by 28 DAT across all growth stages. Analysis of yield (3.2 – 3.7 Mg ha^{-1}) and yield components, including the number of pods per plant (41–54), seeds per pod (2.4–2.6), and hundred seed weight (11.3–13.7 g), revealed no significant differences (slope p-values ranging from 0.219 to 0.948) across the propane doses, torch heights, or soybean growth stages. These results suggest that propane flame weeding, conducted during the flowering stages, does not have adverse effects on soybean yield, indicating it can be a safe weed control strategy during this period.

Critical Time of Cereal Rye Cover Crop Termination in Soybean Planted Green and Early (14)

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Waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] and Palmer amaranth (*Amaranthus palmeri* S. Watson) are among the most challenging weeds to manage in U.S. soybean production systems due to their extended emergence window, resistance to multiple herbicide modes of action, and prolific seed production. Integrated weed management strategies that combine cover crops with residual herbicides have shown enhanced control of these weeds. This study focused on how long cereal rye (*Secale cereale* L.) and early planted soybeans can coexist to maximize cereal rye biomass production without impacting soybean yield. Field trials were conducted using a randomized complete block design with four replications at 9 different states (AR, IL, IN, KS, KY, MO, NE, OH, WI) across the US. The study was established as a 7X2 factorial design with seven cereal rye termination timings based of soybean growth stage (planting, germination, VE, VC, V1, V2, and V3) and two residual herbicide treatments: no residual versus yes residual at cereal rye termination (pyroxasulfone at 183 g ai ha^{-1}). *Amaranthus* spp. plants were counted at the time of the first POST application for each treatment, which was triggered when either ~20% of pigweed plants within a specific treatment reached a height of 10 cm or when soybeans reached the R1 growth stage, whichever happened first. Delaying cereal rye termination resulted in increased biomass accumulation, with the highest levels observed when soybean was at the V2 and V3 growth stages. The inclusion of a residual herbicide at cereal rye termination reduced pigweed density across all termination timings. Soybean yield began to decline with terminations occurring after the VC growth stage, with the greatest yield reductions observed between V1 and V3 compared to termination between at planting and VC. Yield reduction is likely explained by lower soybean stand observed in termination timing V1 to V3 due to suppression of young soybean plants with the advanced cereal rye green stand. The results indicate that soybean can be planted early and green and cereal rye terminated afterwards when soybean reaches the VE-VC growth stages, improving *Amaranthus* spp. control without yield impact.

Assessing Sensors as a Non-Destructive Tool for Weed and Cover Crop Biomass Estimation (15)

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Evaluation of different management practices within cropping systems often involves the use of destructive biomass sampling. For example, the application of cover crops is becoming more popular because they offer several ecosystem services, including minimizing soil erosion, controlling nutrients loss, building up organic matter, and enhancing soil health. These benefits are highly correlated with biomass production. Weeds can highly impact crop yield if left untreated. To understand the influence of different weed management practices, weed biomass is often sampled. Therefore, precise estimation of cover crops and weed biomass should be vital for developing sustainable agricultural operations. However, biomass sampling is time consuming and labor-intensive data to collect. This study investigates the effectiveness of sensors in for non-destructive biomass estimation, the relationship between Remote Normalized Difference Vegetation Index (RNDVI), 3D-NDVI, and fractional green canopy cover (FGCC) with destructively sampled cover crop and weed biomass at different growth stages is being evaluated. This research aims to determine whether RNDVI and 3D-NDVI can accurately quantify and predict cover crops and weed biomass, and whether these sensors outperform FGCC in biomass estimation. The study was conducted at the Greenhouse, located at University of Nebraska-Lincoln, in Lincoln, NE. Four cover crop species were included cereal rye (*Secale cereale*), hairy vetch (*Vicia villosa*), radish (*Raphanus sativus*), and mix of cereal rye + radish and three weed species include green foxtail (*Setaria viridis*), velvetleaf (*Abutilon theophrasti*), and mix of green foxtail + velvetleaf. The cover crop species were broadcasted in a 1,084 cm^2 flat at recommended seeding rate by USDA. The weed species were broadcasted at a rate of 1 g $tray^{-1}$. The study was conducted in a randomized complete block design with five replications. Sensor readings, plant heights, pictures were taken and recorded at 7, 14, 21,28 and 35 days after emergence. Results will be shared at NCWSS conference.

Flame Weeding: An Alternative for Minimizing Cultivation Passes in Organic Corn Production Systems (16)

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Weed management is a critical component of organic corn (*Zea mays* L.) production systems, where herbicides are not utilized. Cultivation serves as the foundation of weed management in organic farming, however, the potential negative soil health impacts associated with excessive cultivation necessitate the adoption of alternative weed control methods that complement physical and mechanical weed management employed in organic production. In 2024, an on-farm research trial was conducted at Timberlane Organic Farms in Bellevue, Ohio, to evaluate the efficacy of replacing a final pre-plant cultivation pass with flame weeding at two application timing in organic corn. The experimental treatments represented variation from the farm's standard weed management practices of multiple pre-planting cultivation passes for cover crop incorporation, seedbed preparation, and weed management, followed by a combination of inter-row cultivation and in-row flame weeding at corn V3/V4 growth stage that served as a positive control. The two experimental flame weeding treatments utilized flame either one week after corn planting but prior to corn emergence (pre-emergence treatment) or 2 to 3 weeks after corn planting when corn had emerged and reached V1 (post-emergence treatment). Plots that did not receive the final cultivation pass or either of the early season flame weeding treatments but did receive the earlier cultivation passes and the V3/V4 cultivation and flame weeding of the farm standard acted as a negative control. Flame weeding was accomplished with 200,000 BTU propane torches mounted on a custom 12-row shielded flame weeder built by the collaborating farmer._Results revealed significant differences in early-season weed density (F=3.85, P=0.009) and late-season biomass (F=9.76, P=0.000007) between the negative control and the other three weed control methods. The post-emergence treatment resulted in a lower mean weed density of 3.95±0.54 compared to other treatments, while the lowest mean biomass was observed in treatments that received pre-emergence control (3.33±1.07 g). The mean density and mean biomass observed in pre- and post-flaming treatments were not significantly (P≥0.05) different from those observed in plots that received standard treatment. These results suggest that flame weeding provides comparable weed control to the standard methods (cultivation). Therefore, it can be used to reduce the number of cultivation passes in organic farming systems. This approach not only minimizes soil disturbance, thereby preserving soil structure and health, but also effectively eliminates weeds before they can set seeds, ultimately reducing future weed populations and seed banks in the soil.

Weed Management Strategies for Establishing Kentucky Bluegrass as a Perennial Cover Crop (17)

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Perennial cover cropping systems have sparked interest because of lower establishment cost compared to annual cover cropping systems and the potential to counteract some of the environmental effects of crop production systems. Implementing this system can limit soil erosion, decrease nutrient leaching, maintain soil moisture, and contribute to managing weeds. There is limited knowledge about herbicides that are compatible with Kentucky bluegrass and what weed management strategies can be successfully employed in this system. We investigated the use of Kentucky bluegrass (*Poa pratensis* L.) as a perennial cover crop in a continuous corn system and explored the weed management strategies for bluegrass establishment. Once the grass has established in the fall, corn is planted into this system the following spring. Establishing slow-growing Kentucky bluegrass as a perennial cover crop can be challenging as it is susceptible to weed competition because of its small seedling size and slow growth rate. To mitigate this, we are employing various weed management strategies during establishment. Our goal is to evaluate treatments that allow the perennial cover crop to establish with minimal weed competition and how the bluegrass can affect corn growth. By investigating the establishment of Kentucky bluegrass as a perennial cover crop, we are seeking to increase the reliability of the system. We are testing four pre-emergent soil residual herbicides applied at grass planting (pendimethalin (also applied after the grass has established), clopyralid, mesotrione, and s-metolachlor), a nurse crop (oats (*Avena sativa L.)*) and a post-emergent herbicide (dicamba). To test how the herbicide effected grass establishment and growth throughout the season, grass biomass and weed biomass, if present, was collected at three separate times in the spring (April), in the summer (June), and in the fall after establishment (September). Anova was conducted on dried grass biomass. For the spring, summer, and fall grass biomass, there was not a significant interaction between the main plot treatment (post emergent herbicide frequency) and subplot treatment (pre-emergent herbicides/nurse crop). The subplot treatment had a significant effect on spring (p <0.001), summer (p= 0.0079), and fall grass biomass (p = <0.001). When *s*-metolachlor was applied pre-emergence, grass did not establish, and this treatment was removed from analysis. We used Dunnett's test to compare each subplot treatment to the control treatment at each sampling date. In the spring, oat nurse crop resulted in lower grass biomass than the control (p<0.001). In the summer there were no treatments significantly different from the control, and for the fall pendimethalin-early (p=0.0495) and oats (p=<0.001) lowered grass biomass relative to the control. Anova was conducted on dried root to shoot biomass and the pre-emergent/nurse crop, post emergent herbicides, and the interaction of them were all not significant. The corn root to shoot biomass was not affected by the amounts of grass present in the various treatments. Anova was conducted on corn yield and there was not a significant interaction between the mainplot treatment and subplot treatment. The subplot treatment had a significant effect on corn yield (p<0.001).

Evaluating Cool-Season Poaceae Species as Perennial Groundcover in Corn (18)

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Integration of perennial groundcover (PGC) into regions with intensive annual crop production can regenerate the natural resource base of once perennialized land, providing ecosystem services such as weed suppression, reduced soil erosion, and increased soil biodiversity. Kentucky bluegrass (*Poa pratensis* L.) has been used as PGC in corn (*Zea mays* L.) production; its shallow rooting system and reduced summer growth, when properly suppressed, minimize the risk of interfering with the corn. However, Kentucky bluegrass is slow-growing, making it susceptible to competition from weeds, commonly resulting in poor establishment in its first year of growth. It is also difficult to suppress, which presents a greater risk of light interference with the corn and a lower corn grain yield. Our overall goal is to determine if alternative cool-season perennial grasses meet key aspects necessary for use in a PGC system, including ease of establishment and lower interference with a corn cash crop. Grasses evaluated include tall fescue (*Lolium arundinaceum* (Schreb.) Darbysh.) varieties turf-type 'FNKY', summer dormant dwarf-type 'Chisholm', dwarf-type 'Barnoble', and forage-type 'KY31' with and without toxic-endophyte presence, as well as perennial ryegrass (Lolium perenne L.) 'Barlibro', and Kentucky bluegrass 'Milagro'. Our specific objectives are to determine (a) the species' ability to provide adequate groundcover to naturally suppress weeds, with and without a spring broadleaf herbicide, and (b) to produce an economically viable grain crop. The grass species were drilled into a field trial (split-plot RCBD) at recommended forage seeding rates on September 18, 2023. The split-plot treatment of the spring broadleaf herbicide, dicamba, was applied early March, 6 months following grass planting, during peak growth of cool-season grasses. Glufosinate was applied two weeks before planting to suppress, or brown, the aboveground grass; the grass was then strip-tilled to remove grass biomass and roots from the corn planting zone. Grass and weed biomass samples and images were collected throughout the first year of growth, and corn grain yield was measured at harvest. ANOVA was conducted on grass biomass collected 2, 7, and 9 months after grass planting. There was no significant interaction between the grass variety and the spring herbicide treatment at 7 months ($p=0.25$) and 9 months ($p=0.42$) of growth. The grass variety was significant ($p<0.001$, for all sampling dates), and the spring broadleaf treatment was not significant at 7 months ($p=0.66$) and 9 months ($p=0.61$) of growth. A Dunnett's test comparing grass biomass to 'Milagro', Kentucky bluegrass, indicated that all varieties, excluding 'FNKY', had higher biomass at 2 and 7 months of growth ($p<0.01$). ANOVA was conducted on grain yield; the grass variety was significant ($p=0.03$). 'Milagro' had the highest mean grain yield (11.68 t ha^{-1}), 14.6% higher than 'Barlibro' with the second highest grain yield (8.97 t ha^{-1}), followed by 'KY31 toxic-endophyte free' (8.82 t ha^{-1}), 'Chisholm' (8.12 t ha^{-1}), 'KY31' (7.13 t ha^{-1}), 'FNKY' (5.71 t ha^{-1}), and 'Barnoble' (5.17 t ha^{-1}). According to our 2023-2024 field results and previous literature, Kentucky bluegrass as a PGC remains more suitable for corn production than the alternatives evaluated.

Poster Section – Extension

On-Farm Insights: Farmer Perspectives on Harvest Weed Seed Control in Minnesota Corn and Soybeans Production (19)

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Harvest Weed Seed Control (HWSC) refers to a group of weed management tactics that aim to collect and destroy weed seeds at crop harvest, reducing the weed seed return to the seedbank. One of the HWSC methods is the use of an impact mill (also known as a seed destructor, hammer mill, or cage mill), which attaches to the back of a combine harvester to mechanically destroy or pulverize weed seeds that are present in the chaff. This technique has been adopted in several cropping systems worldwide, offering farmers an additional weed management tool, integrated into their normal harvest operations. While HWSC holds promises to minimize weed seedbank and herbicide resistance, its success depends on the geographic area, crop, and weed species. A Minnesota farm utilized the Redekop Seed Control Unit (SCU), an integrated cage mill, for two years (2023 and 2024) in both corn and soybean. This equipment testing was a part of a GROW (Getting Rid of Weeds)-initiated multistate project. This poster focuses on evaluating the farmers' perspectives on the feasibility of this technology in corn-soybean rotation. The farmers noted positive aspects, including a reduction in the weed seedbank, which could help to mitigate the spread of herbicide-resistant weeds. They recognized the value of having a novel weed management tool in the toolbox. However, several challenges were highlighted, including the high upfront cost of the SCU and increased fuel consumption during harvest, both of which may affect overall profitability. Farmers also expressed concerns about a potential slowdown in harvesting when using the SCU. Despite these issues, the long-term benefits of HWSC may outweigh these difficulties, particularly in fields with a high prevalence of herbicide-resistant weeds.

Poster Section - Herbicide Application Technologies

Spray Characteristics and Efficacy of Glufosinate-Ammonium Formulations under Greenhouse Conditions (20)

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The emergence of herbicide-resistant weed species has intensified the need to evaluate and optimize existing herbicide application strategies in row crops. Among these, glufosinate-ammonium formulations have induced significant attention for their broad-spectrum efficacy and the growing availability of diverse formulations in the marketplace. The objectives of this study are to evaluate the deposition characteristics and biological effects of ten different glufosinate-ammonium formulations (656 g ai ha^{-1}) on weed species, including Palmer amaranth, common lambsquarters, velvetleaf, and non-glufosinate-tolerant corn. Additionally, the study aims to assess the impact of integrating a spray additive (0.5% v/v) under controlled conditions, comparing treatments with and without the additive to evaluate not only their efficacy but also their deposition performance. The application was performed when weed species were 10-15cm in height. The spray chamber was calibrated to apply 140 L ha^{-1} at 276 kPa using a dual-fan TTJ11003 nozzle, operating at a 3.53 m s^{-1}. Solutions containing food-grade dye (3 g L^{-1}) were sprayed onto kromekote cards to assess deposition characteristics. Additionally, the physical properties influencing deposition, such as density and kinetic viscosity, were evaluated to understand their impact on spray performance further. The biological effects were quantified through visual assessments, using a percentage scale from 0 (no impact) to 100 (complete control), conducted over up to 28 days post-application. After this period, the plants were harvested, dried to constant biomass, and weighed to determine the percentage of biomass reduction compared to the non-treated control, which was used for further statistical analysis. The study results highlight the differentiation in formulation responses when incorporating spray additives in a tank mix. Some formulations experienced considerable changes in viscosity and coverage, while others remained more stable. This emphasizes the varying impact of additives on formulation performance, suggesting that each should be evaluated based on specific application needs. Results indicated no differences in Palmer amaranth and velvetleaf biomass reduction across the different formulations tested. However, some formulations demonstrated reduced efficacy in non-glufosinate-tolerant corn and common lambsquarters. For corn, formulations 5 and 9 exhibited reduced efficacy in corn, with formulation 5 showing the most negligible impact on biomass reduction, although it improved when a spray additive was included. Conversely, in common lambsquarters, all formulations with a spray additive resulted in similar levels of biomass reduction, while formulation 9 alone achieved only a 53% reduction; however, adding the spray additive enhanced this effect to 93%. These findings suggest that the formulations perform similarly, but their effects may differ depending on plant species. Future research should evaluate these findings under field conditions to confirm whether the observed trends persist, enhancing the practical relevance and application of these formulations in real-world settings.

Do Variable Rate Applications of Soil Residual Herbicides on Variable Field Soils Result in Greater Herbicide Availability in the Soil Solution? (21)

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Herbicide availability in the soil solution is driven by a variety of physiochemical properties of the soil and herbicide molecule. This variability of free herbicide in the soil solution determines the potential biological effect, which drives product label rate recommendations for soil residual herbicide applications. Fields with high soil variability may not allow a single, uniform application rate across the entire field and meet these application rate ranges to optimize residual weed control, with minimal ensuring crop safety by avoiding overapplication. New application technology could allow for the variable rate application of these soil residual herbicides by soil type, but how well will this translate to the concentration of the herbicide available in the soil solution? We hypothesize at the label recommended herbicide rate for each soil type, the herbicide concentration in soil solution will be equal. Therefore, the objective of this experiment was to quantify the concentration of herbicides in the soil solution following variable rate application of the herbicides in fields with spatial variation in soil types, using a novel combination of methods.

Field trials were established in 2023 and 2024 on two commercial fields with high soil variability, previously mapped through electrical conductivity and confirmatory grid soil sampling. Variable application rates were determined by label recommendations for the major soil texture and organic matter classes present in the field resulting in a “low”, “medium”, and “high” rate of sulfentrazone and cloransulam. Plots were arranged in a randomized complete block design with four replicates and placed on the three most abundant soil types present on the fields. Soil samples were collected 8 cm deep using a probe measuring 7 cm in diameter. Soil samples were collected immediately after residual herbicide application and immediately prior to the planned postemergence application. Two soil extraction methods were performed to quantify the total and available (free in the soil solution) herbicide concentration. Total herbicide concentration was extracted using a modified QuEChERS method with magnesium sulfate and sodium acetate as extraction solvents. Soil solution herbicide was extracted using a centrifugation method proposed by Dao and Lavy (1978), modernized by Kah and Brown (2007), and successfully utilized for weed science research by Bukun et al. (2010). A 1260 Infinity HPLC was used to quantify concentrations of herbicide using diode array detection, a C18 column and acetonitrile and water as injection solvents. These data were analyzed by a two-way ANOVA in R studio using soil type and herbicide rate as explanatory variables for herbicide concentration. This research could provide an efficient method for quantification of herbicide concentrations in soil solution and demonstrate the efficacy of variable rate soil residual herbicide applications.

Effect of Carrier Volume on Waterhemp Control with a Drone (22)

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Advances in drones or unmanned aerial vehicles (UAVs) are making aerial pesticide applications more viable. There are many instances where the use of drone sprayers for herbicide applications could be helpful to manage weed escapes for soybean growers. A large-scale field experiment was conducted in Michigan. When 'Enlist E3' soybeans were at the V4-V5 soybean stage and glyphosate-resistant (GR) waterhemp averaged 20-cm tall (5-45 cm), 7.6 wide by 152 m long plots were set up for drone applications. Additional weeds present were giant foxtail (*Setaria faberi*), common lambsquarters (*Chenopodium album*), and GR horseweed (*Conyza canadensis*). 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 with a XAG P100 Pro 2023 drone 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). Each treatment was replicated 4 times. At 7 and 14 days after treatment (DAT) weed control was evaluated. Evaluations were taken at three different areas in each plot as subsamples. Regardless of application method, all treatments controlled giant foxtail (95% or greater) and common lambsquarters (100%) similarly. The greatest control of waterhemp was 72% with glufosinate that was applied at the slower speed (6.99 m sec^{-1}) with a drone 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 (9.5 m sec^{-1}) was similar to waterhemp control from the ground rig. GR-horseweed control was also highest (100%) with the 46.8 l ha^{-1} at drone application at 6.99 m sec^{-1}. This was similar to the ground rig at 178 l ha^{-1} and also the 28 and 46.8 l ha^{-1} at 9.5 m sec^{-1} drone application. Overall, weeds that are normally easily controlled with glyphosate, giant foxtail and common lambsquarters, application volume and drone speed did not affect control. Drone applications also provided good control of GR horseweed similar to the ground rig. A minimum of 28 l ha^{-1}, regardless of application speed, was needed to provide GR waterhemp control similar to the ground rig. However, GR waterhemp control was unacceptable and additional control measures would be needed. Further research is needed to continually investigate weed control with drone applications.

Aerial Monitoring of Crop Development and Weed Control Using UAVs (23)

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Unmanned aerial vehicles (UAVs) are revolutionizing agricultural practices by enabling more precise monitoring and management of crop and weed growth. This study evaluated the integration of FieldAnalyzer software with the Mavic 3M UAV for aerial monitoring, based on data collected from two field experiments conducted in 2024 at Janesville, WI. The first experiment focused on crop response to assess the postemergence (POST) effects of glufosinate (656 g ai ha^{-1}) and PPO-inhibitors fomesafen (263 g ai ha^{-1}) and lactofen (219 g ai ha^{-1}) on soybean development 28 days after treatment (DAT), applied solo and in tank mixtures. All POST treatments included ammonium sulfate (1,428 g ha^{-1}), crop oil concentrate (1% v/v), and pyroxasulfone (91 g ai ha^{-1}). Three spray nozzles with different spray classifications (XR110015-Fine; AIXR110015-Coarse; and TTI110015-Extremely Coarse) were evaluated in a 7x3 RCBD factorial design, along with weed-free and weedy controls, replicated four times. The second field experiment investigated waterhemp control from five treatments, including a nontreated control in bareground conditions (no crop) 14 DAT. In this experiment, glufosinate (656 g ai ha^{-1}) and 2,4-D (1065 g ai ha^{-1}) were applied POST when waterhemp reached 10 cm in height, with ammonium sulfate added at 1,428 g ha^{-1}. Herbicides were applied solo and as both a tank mix and a simulated dual-tank (separately within a single application). Carrier volume for both experiments was 140 L ha^{-1}. In the crop response experiment, visual injury was estimated, and herbicide effects on soybean development were assessed using both orthomosaic (18 m height) and single-photo imagery (88 m height). Consistency between these imagery methods and ground-truth visual data collection was compared. In the bareground experiment, visual waterhemp control and only single-photo imagery (30 m height) was taken. Images were analyzed using FieldAnalyzer software, which quantified green pixel counts within experimental units. Data were subjected to ANOVA and canopy cover between the two imagery methods from crop response study was compared using a linear regression model. In the crop response experiment, both herbicide treatments and nozzle types had significant effects on crop response ($P<0.05$), with the greatest soybean injury occurring from treatments containing lactofen at 28 DAT with both photo-taking methods, corroborating with visual data. TTI110015 (Extremely Coarse spray) caused the least injury to soybean, and the XR110015 caused the most (Fine spray), while the effect of AIXR110015 (coarse spray) was similar to other two nozzles. Single-photo imagery explained 86% of the variability in orthomosaic canopy coverage ($R^2=0.86$) collected in the crop response study, suggesting that single-photo methods may offer flexible, time-efficient options for capturing high-quality data, while relationship between visual and digital estimators was $R^2=0.70$. In the bareground experiment, herbicide treatments were significant ($P<0.05$), with the glufosinate + 2,4-D combinations achieving the lowest weed cover (4-6%), followed by glufosinate (16%) and 2,4-D alone (45%), aligning with visual waterhemp control results. Integrating FieldAnalyzer with UAVs offers a reliable tool for precision agriculture, providing timely, accurate field insights. As UAV technology advances, tools like FieldAnalyzer are expected to become more valuable for in-field data collection.

Combining Targeted Herbicide Application and Drone Imagery (24)

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Effective weed management is essential for optimizing crop yield and reducing input costs, yet traditional blanket herbicide applications are often environmentally unsustainable. To address these issues, it is possible that imagery collected with an unmanned aircraft system (UAS) prior to application could be used to spatially monitor the field for targeted application and identify site-specific solutions. Logistical issues need to be answered for successful adoption of targeted herbicide application technology. A case study was conducted in conjunction with Ag Partners Cooperative (Seneca, KS) and Taranis (Tel Aviv, Israel) to determine the capabilities of UAS imagery services provided by Taranis as it pertains to targeted herbicide application. One soybean field near Hiawatha, KS was identified for collection of UAS imagery, weed counts, and targeted herbicide application. Manual weed counts were conducted on June 10, 2024 when soybeans were in the cotyledon stage (VC). Weeds were identified and counted from six locations in the field that were categorized as high, low, or zero weed density. Images were collected on June 11, 2024 via Taranis UAS mission. The mission was conducted using a DJI Matrise 350 RTK UAS system with acquisition density of eight images per acre. Taranis Artificial Intelligence was used to locate and identify weeds in the UAS images. Postemergence herbicides were then applied using a John Deere See & Spray Ultimate on June 12, 2024. As-applied data was compared to weeds identified by Taranis, and manual weed count data were used to verify both maps. Comparison between manual weed counts and Taranis weed tags showed moderate correlation. The Taranis imagery did not clearly show the contrast between medium and high weed densities seen in the manual counts. However, it correctly identified the areas with no weeds, matching the manual observation of the clean spots on the imagery. When comparing Taranis tagged weeds with the as-applied data from the See & Spray Ultimate, it was noted that there were many areas where Taranis tagged no weeds, yet the machine still applied herbicide. Less area would have been sprayed if the targeted application was based solely on the Taranis weed map rather than See & Spray optical detection. Finally, manual weed counts were compared to the as-applied data, and it was noted that all manual sample locations were applied with herbicide by the See & Spray Ultimate regardless of observed weed density. The sample location with no weeds present was sprayed, and at the full application rate. The as-applied data also indicated that a large area surrounding this weed-free location was treated by the machine, confirming that the application was not due to the turn on/turn off timing.

Palmer Amaranth Control with Tembotrione and Adjuvants (25)

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As noted in surveys conducted in Nebraska in 2015 and 2020, Palmer amaranth (*Amaranthus palmeri* S. Watson) has become one of the most troublesome weeds in corn and soybean production. Dicamba and 2,4-D (WSSA Group 4) have been important postemergence tools in corn and soybeans for several years. Overreliance on these herbicides in a corn-soybean rotation may lead to selection pressure and development of resistance. A postemerge alternative in corn is tembotrione (WSSA Group 27). Available herbicide label suggests adding a nitrogen source (ammonium sulfate, urea ammonium nitrate) and an oil adjuvant to the spray solution. A greenhouse study was conducted to evaluate the effectiveness of tembotrione (92 g ae ha^{-1}) on Palmer amaranth control when adding different types of oil adjuvants (crop oil concentrate, methylated seed oil, high surfactant crop oil concentrate, and high surfactant methylated seed oil). An additional factor included treating Palmer amaranth with dicamba (280 g ae ha^{-1}) and after several days making the tembotrione treatments. Treatments with atrazine and mesotrione were also included. Visual evaluations at 28 days after treatment showed similar Palmer amaranth control among the oil adjuvants, with all outperforming tembotrione alone. Fastest control was observed with atrazine in the tank-mix, but crop stage limitations exist with atrazine in corn.

Impact of Activator Adjuvants With and Without a DRA on Spray Drone Swath Characteristics (26)

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Herbicide labels frequently require the use of an activator adjuvant to optimize herbicide performance, but deposition aids and drift reduction agents (DRA) are generally left to the discretion of the applicator or grower. Spray drone applicators will commonly include a deposition aid or DRA with the spray solution. Previous research has demonstrated adjuvants may alter the effective swath width of drones depending on adjuvant composition and use rates. A field experiment was conducted to evaluate activator adjuvants applied with and without a DRA on the effective swath width, spray coverage, and spray deposition in a drone application. Spray adjuvant treatments included four activator adjuvants [nonionic surfactant (NIS), crop oil concentrate (COC), methylated seed oil (MSO), high surfactant oil concentrate (HSOC)] applied alone and in combination with a guar-based DRA. All treatments included a pink foam marker dye (0.375% v/v), and a fluorescent tracer dye (600 µg ml^{-1}). A DJI Agras T30 equipped with 12 XR80015 nozzles calibrated to deliver 18.7 L ha^{-1} at a height of 3 m and an assumed effective swath width of 6 m was used to apply treatments. Oil-sensitive and acetate cards were spaced every 46 cm along a transect that was 11 m long, approximately 10 cm above the ground surface, and oriented perpendicular to the flight path. Continuous bond paper was also placed in the halfway down the flight path. Average spray coverage across the entire swath was greatest with NIS (3.9%) and MSO (3.6%) either applied with or without the DRA. As expected, the inclusion of the DRA resulted in decreased deposit density from the reduction of fine droplets. Across the assumed effective swath width, coefficients of variation values calculated from spray card coverage (25 to 49%) and spray card deposition (28 to 67%) demonstrate a high degree of non-uniformity across the spray swath for important spray quality measures. The calculated effective swath width ranged from 3.2 to 7.8 m, with MSO and HSOC resulting in the greatest effective swath width when applied alone. The NIS and COC treatments decreased the effective swath width by at least 8% compared to the assumed effective swath width by 0.46 m and 1.98 m, respectively. The inclusion of the DRA further decreased the effective swath width by 0.46 to 2.9 m compared to each activator adjuvant applied alone. The only exception to this collapse of the spray pattern was for HSOC, which increased the effective swath width by 0.3 to 0.61 m. The activator adjuvants inconsistency influenced effective swath widths, which may limit flexibility for different herbicide applications with spray drones. Further research is justified to evaluate other deposition aids or DRAs to achieve a more consistent swath width when applied across activator adjuvant categories.

Early Detection of Herbicide-Resistant *Amaranthus tuberculatus* Populations Using Drone-Mounted Multispectral Imaging (27)

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Waterhemp (*Amaranthus tuberculatus* (Moq.) J.D. Sauer) is the most troublesome weed in soybean fields in the Midwest. To date, it has evolved resistance to seven herbicide site of action (SOA) groups (2, 4, 5, 9, 14, 15, and 27) in Illinois. Therefore, early detection of herbicide-resistance in waterhemp populations using drone-mounted multispectral imaging offers opportunities for an early proactive approach. An experiment was conducted at the Southern Illinois University (SIU) Agronomy Research Center, utilizing a Micasense RedEdge-MX DUAL multispectral camera mounted on a DJI Inspire II drone. The experiment included five populations: two suspected-resistant (Franklin and Saline) and three susceptible (BRC, Carlyle and Washington). Plants were grown in greenhouse conditions, and leaf samples were collected when plants reached 7.5 to 10 cm height. Leaf disk samples (6 mm diameter) were taken using a leaf punch and placed in a 24-well polystyrene microplate with a flat bottom and a low evaporation lid. In each well, 1 ml of herbicide solution containing glufosinate at one of six rates (163 [0.25x], 327 [0.5x], 654 [1x], 1310 [2x], 2620 [4x], and 5230 [8x] g ai ha^{-1}) plus AMS at 2.5% v.v. was added, along with a nontreated control. The 1x rate represents the full field rate for postemergence applications. Samples were placed in a lightbox, and images were taken every two hours for 48 hours. Analysis of the multispectral data focused on the Green-560, Red-650, and Green Leaf Index (GLI) bands. The Green-560 band exhibited a linear decrease (r^2=0.78) in response to increasing herbicide doses across all populations within the first two hours after treatment (HAT). The Franklin and Saline populations, suspected to be resistant to glufosinate, had lower Green-560 values than the susceptible populations (BRC, Carlyle, and Washington). Green-560 values decreased quicker in BRC (slope = -4.5) than those of Franklin (slope = -3.3) by the increased dose of herbicide at 2 HAT. Additionally, the GLI values from the blue camera highlighted differences between these populations, with Franklin showing a lower GLI (slope = -0.20) compared to BRC (slope = -0.27) at 2 HAT. Over the 48-hour observation period, Green-560 values increased linearly (r^2=0.77), with sustained differences between the BRC and Franklin populations, while Red-650 did not exhibit significant population-based variation. Red-650, however, effectively differentiated between the control and herbicide-treated, although Green-560 demonstrated greater sensitivity to herbicide doses. Furthermore, GLI from the blue camera successfully distinguished susceptible and resistant populations under increasing herbicide doses. In conclusion, multispectral imaging, particularly the Green-560 and GLI bands, proved effective in early detection of herbicide-resistant waterhemp populations. Further research is underway to refine these imaging techniques, aiming to improve the accuracy of early resistance detection strategies across various weed species and herbicides.

Spray Deposition of Different Glufosinate Formulations with Single and Dual Fan Nozzles (28)

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Advancements in formulation technology have led to the development of products aimed at reducing off-target movement, such as physical drift. The trend is evident in the variety of glufosinate-ammonium formulations in the marketplace. The availability of diverse formulations has prompted inquiries into their differential effects beyond efficacy, particularly concerning drift, highlighting the need for a comparative assessment to guide application strategies effectively. Since glufosinate-based herbicides are contact herbicides that require extensive leaf coverage, selecting the appropriate spray tip is crucial. The tip selection should balance achieving the smallest droplet size allowed by the product label to maximize coverage while minimizing the risk of drift. The objective of this study was to assess potential differences among various glufosinate formulations applied at 656 g ai ha^{-1} using single (TT11003) and dual fan (TTJ11003) nozzles in a low-speed wind tunnel with an airspeed of 4.47 m s^{-1}. Spray solutions were prepared at 140 L ha^{-1}, containing fluorescent tracer at 1 g L^{-1}. The nozzles operated at 276 kPa and were positioned perpendicularly to wind flow to simulate a worst-case drift scenario. Mylar cards were placed at distances of up to 12 meters downwind to capture deposition. Spray deposition for each solution was quantified by fluorometric analysis. Mylar cards were washed in 30 mL of 10% alcohol solution and prepared with 90% distilled water. A four-parameter log-logistic function with the *DRC* package in R to fit the data. The results suggest that the different types of formulations and TT and TTJ nozzles can impact the amount of spray deposition downwind. For the TT nozzle, formulations varied in drift potential, with Glufosinate 9 showing the highest drift (2.23 m) and Glufosinate 3 the lowest (1.50 m). Glufosinate 3 did not differ from formulations 5, 6, and 7, while it responded differently from the other formulations. Similarly, spray deposition varied across formulations with TTJ nozzles, with water showing the highest drift (1.90 m) and Glufosinate 7 the lowest (1.30 m). Glufosinate 3 had similar drift potential to formulations 2, 4, and 6 but exhibited lower deposition than Glufosinate 9. Even though findings indicate that the TTJ tip may mitigate drift more effectively for the treatments hereby tested with varying responses across tested formulations, additional measures to reduce drift are necessary to alleviate drift even further. Beyond selecting the appropriate spray tip, it is essential to consider implementing additional strategies, such as using additional spray additives.

Do Postemergence Herbicide Application Timing and Strategy Impact Weed Control and Foliar Herbicide Savings when using Targeted Application Technologies? (29)

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Herbicide applications play a key role in weed management, requiring precision and efficiency to meet grower, society, and regulatory requirements. Novel emerging herbicide application technologies, such as the smart sprayer by One Smart Spray BASF-BOSCH joint venture, offer the ability to apply foliar herbicides precisely where weeds are present, in contrast to traditional broadcast sprayers which spray entire fields. Application of preemergence (PRE) herbicides can reduce the number of weeds emerging early in the season, increasing the value of these technologies. Additionally, including residual herbicides in a tank mix with postemergence (POST) herbicides can enhance season long weed control reducing the need of multiple POST applications. In 2023 and 2024, field studies were conducted in Seymour, IL and Janesville, WI to compare POST weed control across traditional broadcast application, spot spray application only of foliar herbicides or foliar and layered residual herbicide, and spot spray of foliar herbicides with broadcast application of a layered residual herbicide through the 2-boom 2-tank system at two different application times (early versus late). Application time "early" was triggered when soybeans were at V2 growth stage and "late" when soybeans were at V4 growth stage. The studies were arranged in a randomized complete block design with four replications. All treatments received a broadcast PRE herbicide application of saflufenacil 24 g ai ha^{-1} + dimethenamid-P 215 g ai ha^{-1} and were treated with glufosinate 655 g ai ha^{-1} + glyphosate 1,551 g ha^{-1} and + or - S-metolachlor 734 g ai ha^{-1} POST according to the respective treatment modality (i.e., broadcast, spot spray, 2-tank 2-boom system). Visual weed control and biomass data were collected 28 days after the late application timing. In 2023, results from Seymour, IL showed that the late application timing provided better weed control (>88%) but lower herbicide savings (26%). For the early POST application where higher savings of foliar herbicides was detected (76%), the addition of a layered residual herbicide was necessary to provided more effective control (89-92%). In 2024, with low weed pressure at Seymour, IL there was no difference in weed control (>95%) and herbicide savings (>67%) between application timings. However, under incredibly high weed pressure in Janesville 2024, the highest levels of weed control was 89%, regardless of modality, and savings were incredibly low (2%); an additional POST herbicide application would have been necessary for effective (>90%) end of season weed control. Our results suggest that the late applications provided more effective weed control, assuming effective foliar herbicides are available. Early applications with residual herbicides offered greater savings opportunities for foliar herbicides. Our results indicate that the benefits of targeted application technology are most visible in fields with low to intermediate weed pressure treated with an effective PRE herbicide program. In scenarios with high weed pressure, a broadcast application may be a more effective option.

Weed Management with Broadcast, Hooded, and Individual Row Crop Sprayers (30)

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Controlling weeds is challenging in Midwest areas due to extended weed emergence over the season. After crop establishment, controlling newly emerging weeds becomes difficult due to overlapping canopies of weeds and crops. Unfortunately, applications in mid-to-late season are less practical due to crop canopy interception of the spray solution. In addition, an overlaying residual herbicide application postemergence (POST) could be a positive addition to season-long weed control. Therefore, this study aimed to evaluate hooded sprayers for late POST applications with and without an extender to prolong the efficacy of the residual product applied as part of the tank-mix. A field trial was conducted in 2024 to evaluate a residual extender applied with broadcast or hooded sprayers for residual weed control in crops. Soybeans (2,4-D tolerant) were planted May 14 and herbicide applications made at V5 on June 25. Plots were 4.6m x 15.2m and arranged in a randomized complete block design with 6 replications. Herbicide treatments consisted of postemergence applications of a tank mix of 656 g ai ha^{-1} glufosinate, 1054 g ae ha^{-1} of glyphosate, 1064 g ae ha^{-1} of 2,4-D (choline salt) and 1067 g ai ha^{-1} of S-metolachlor. The tank mix was applied with and without 2.3 L ha^{-1} of extender. Broadcast sprayer herbicide applications were applied at 187 L ha^{-1} at 286 kPa with Wilger MR110-05 nozzles. Applications with the hooded sprayer with 2 nozzles were applied at 187 L ha^{-1} at 286 kPa with Wilger MR110-02 nozzles. Applications with the hooded sprayer with 3 nozzles were applied at 187 L ha^{-1} at 229 kPa with Wilger MR110-15 nozzles. Visual control ratings of Palmer amaranth (*Amaranthus palmeri* S. Watson) and bristly foxtail (*Setaria verticillata* L. Beauv.) were taken in and between crop rows at 30 DAT. For Palmer amaranth control, the extender had no impact on control. There was a significant effect of application, with the broadcast application resulting in higher control than the hooded sprayer with three nozzles. In addition, control of Palmer amaranth was higher between rows (76%) compared to in-rows (44%). For bristly foxtail, there was a significant interaction of application (sprayer type) by location (in row vs. between rows) with broadcast applications resulting in the highest control of 99% between rows and 90% in rows. Results of this study indicate there was no benefit to using an extender for Palmer amaranth or bristly foxtail control. In addition, using a hooded sprayer with either 2 or 3 nozzles per row resulted in lower control than the broadcast applications. Performance differences were likely due to the change in droplet size resulting from varying nozzle sizes and pressures at application. In addition, there may have been physical contact between the hood and the weeds in between rows. Future research will focus on evaluation of extender in areas with no existing emerged weeds.

Comparison of UAV and Ground Sprayer for Pre-Emergent Herbicide Application in Soybean (31)

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As the use of unmanned aerial vehicles (UAV) for herbicide applications increases, research is needed to understand UAV performance compared to conventional ground sprayers. Effective applications of pre-emergent (PRE) herbicides play an important role in soybean (*Glycine max*) production to help maintain yields and mitigate and/or manage herbicide resistant weed species. A field experiment was conducted in 2024 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. Multispectral drone imagery along with visual weed control ratings were taken at 7, 14, 28, and 42 days after crop emergence (DAE). A Normalized Difference Vegetation Index (NDVI) calculation was made in each plot as a measurement of successful weed control. UAV treatments exhibited significantly less spray coverage and smaller droplet sizes when compared to the ground sprayer. However, off-target spray movement was not different between the ground sprayer and UAV. There were no visual differences in weed control between any of the treatments evaluated but NDVI values were lower at 14, 28, and 42 DAE in plots sprayed with the ground

sprayer compared to the UAV, indicative of higher PRE weed control. Overall, results indicate that the UAV parameters evaluated in this research did not significantly affect spray coverage or off target movement. However, the ground sprayer provided higher coverage, increased droplet sizes, and potential improvements in PRE weed control in soybean.

Investigating the Herbicide Formulations: Efficacy of Nano-glyphosate and -glufosinate (32)

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Despite the extensive use of herbicides, weed control poses a significant challenge to crop yield losses around the world. A novel weed control strategy that reduces the volume of herbicide used while maintaining efficacy would enhance farm productivity and reduce negative effects on applicators and the environment. Nano herbicide formulation is an exciting approach with the potential to minimize soil residues, reduce application rate, and precisely penetrate the weed's cuticle. The objective of this study was to compare control of velvetleaf (*Abutilon theophrasti*) and sorghum (*Sorghum bicolor*) by nano-formulations and commercial formulations of glyphosate and glufosinate. A half and a full dose of glyphosate (RoundUp PowerMax 3,640 and 1,280 g ai ha^{-1}) and glufosinate (Liberty 280 SL, 300 and 600 g ai ha^{-1}) were sprayed as both commercial and nano formulations. Nanoparticles were synthesized using the ball/milling technique on activated charcoal. The material was milled for 30 minutes at 15 HZ and compared to non-milled charcoal with herbicide. The nanoparticles were collected from the mill and placed in a falcon tube with 5 mL of water and shaken for 2 minutes to obtain coverage of the herbicides on the nanoparticles. Herbicides were applied when velvetleaf and sorghum were 10 cm tall. Treatments were replicated four times, and the entire experiment was conducted twice. Visual injury data was collected at 1 and 3 weeks after application (WAA) along with dry biomass at 3 WAA. Results suggest that the nano formulations (half and full doses) of both herbicides showed two to four times greater leaf injury in sorghum and velvet leaf compared to their respective commercial formulations. In addition, milling charcoal resulted in 60% greater visual injury compared to the non-milled formulation (5%). This study will contribute to future investigations into the effectiveness of nano herbicide formulations as a sustainable weed management approach.

Evaluating Different PPO-inhibitor Rates in Tank-Mix with Glufosinate on Control of Velvetleaf and Common Lambsquarters (33)

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Burndown is an essential management strategy for reducing weed competition with cash crop. Starting with a clean field gives the cash crop an initial competitive edge and makes it easier to manage weeds throughout the season. However, some challenges arise during burndown, such as low control of certain weed species and high incidence of herbicide-resistant plants. Research suggests that tank-mixing herbicides with different modes of action, such as glutamine synthetase (GS) inhibitors and protoporphyrinogen oxidase (PPO) inhibitors, can provide more effective control than applying them individually. The synergy between these herbicides results from their combined action, which leads to the accumulation of reactive oxygen species, causing lipid peroxidation in cell membranes and ultimately cell death. This synergy is especially useful for "tough-to-control" weeds like velvetleaf (*Abutilon theophrasti*) and Common lambsquarter (*Chenopodium album*), which are difficult to be controlled by a broad-spectrum herbicide. A bioassay study was conducted in a greenhouse at University of Nebraska-Lincoln, located in Lincoln, NE. The study aimed to evaluate the efficacy of control provided by different synergistic dose combinations of glufosinate (glutamine synthetase inhibitor) and fomesafen (PPO inhibitor) on velvetleaf and common lambsquarters. The bioassay consisted of 14 treatments, glufosinate and glufosinate + fomesafen, including a control (non-treated). Glufosinate+fomesafen treatments consisted of rate combinations, where glufosinate at 2.3 and 1.2 L ha^{-1} were tank-mixed with fomesafen at 0, 0.075, 0.15, 0.3, 0.6 and 1.2 L ha^{-1}. The weeds were targeted to be sprayed between 15 to 25 cm height. Data collection consisted of weekly evaluations of plant height, visual control (%), pictures and aboveground biomass at 21 days after herbicide application. The outcomes of this bioassay will be shared at NCWSS conference.

Utilizing a Fluorescent Pigment to Measure the Influence of Adjuvants on Spray Solution Coverage (34)

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Adjuvants can influence deposition and coverage of herbicide tank-mixtures on target pests. Maximizing spray coverage can improve herbicide efficacy, especially with contact herbicides. Current methods for measuring spray deposition and surface coverage are limited to artificial surfaces used to capture droplets that lack the characteristics of leaf surfaces. The first objective of this study was to develop a method to quantify spray deposition and coverage of herbicide tank-mixtures using leaf surfaces and an indicator that does not change droplet characteristics. The second objective was to measure the influence of adjuvants on spray coverage on a weed species. A fluorescent pigment spray coverage method was developed and confirmed in this study. Herbicide tank-mixtures containing 2,4-D and various adjuvants were applied in a controlled spray application chamber with a fluorescent pigment. Quantification of spray solution coverage was conducted by image analysis with images of treated leaves under normal and UV-light conditions. In this study, 62% of the velvetleaf surface was covered by the spray solution when 2,4-D was applied alone. Coverage was increased to 73-86% when adjuvants were included with 2,4-D. Tank-mixtures with more surfactant content resulted in greater leaf surface coverage. A limitation of this method is differences in leaf surface, overlap, and evenness can result in data with high variability between samples. Increasing replications or removing outliers to improve statistical power may be necessary with this method. The fluorescent pigment method developed in this study can be utilized in the future for investigating adjuvants in combination with other herbicides, weed species, and environmental stresses.

Influence of Commercial and Experimental Deposition Aid Adjuvants on Spray Parameters with Spray Drones (35)

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Spray drones are gaining popularity for applying pesticides, but research data is sparse on the effectiveness of these applications with herbicides. Spray adjuvants, classified as deposition aids, have been tank mixed with herbicides in traditional aerial application systems and shown to have a varying influence on the spray swath, spray coverage, droplet size, droplet density, and pesticide efficacy. Common components of deposition aids include methylated seed oils (MSO), crop oil concentrates (COC), guar gum polymers, polyvinyl polymers, and other polymer blends. Our research objective was to evaluate commercial and experimental deposition aids for improving spray drone applications in terms of spray coverage and deposit density on targets. Spray drone application treatments consisted of a no adjuvant control, four commercial adjuvants, and three experimental adjuvants applied with blue dye for deposit visualization. Applications were made with a DJI Agras T30 spray drone equipped with 12 TeeJet AIXR 110015 nozzles at a travel speed of 7 m s^{-1}, a spray height of 3 m, and an assumed swath width of 7.6 m. Spray deposits were collected on a 15 m long swath paper positioned in a perpendicular orientation along the flight path and located at 30, 45, and 60 m away from the front of the plot. The extent of spray coverage across the entire swath was minimal, ranging from 2.8% to 6.4% for all treatments. An increase in spray coverage was observed with two experimental products (6.1 and 6.4%) compared to no adjuvant (3.2%). Spray deposit density ranged from 2.1 to 9.4 deposits per cm^2 and was not consistently associated with spray coverage. Some adjuvant treatments with low spray coverage had the same density of spray deposits as treatments with the highest spray coverage. Overall, the CV values varied widely between treatments (51% to 100%); however, there were no significant differences when compared to no adjuvant. In conclusion, the use of adjuvants in drone applications may increase the spray coverage but have varying effects on deposit density and did not appear to help reduce the large CV values across the spray swath that is problematic for these applications. Additional research is needed to validate and develop new adjuvant formulations that are optimized for spray drone applications, as well as evaluate their effect on herbicide efficacy.

Antagonism of Clethodim from pH Buffers Used with Dicamba (36)

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The widespread adoption of dicamba- and 2,4-D-resistant soybean varieties across the United States has enabled farmers to spray Group 4 herbicides postemergence to control glyphosate-resistant broadleaf weeds. However, previous research indicates that adding Group 4 herbicides and glyphosate may antagonize clethodim efficacy on volunteer corn. The dicamba herbicide labels for postemergence applications in dicamba-resistant soybeans (vacated in early 2024) required the addition of drift reduction agents (DRA) and pH buffers. Two greenhouse experiments were conducted in 2024 to evaluate the effect of dicamba formulations, spray adjuvants, a DRA, and pH buffers on volunteer corn control with clethodim. The first experiment included tank mixtures of the herbicides clethodim, dicamba (BAPMA salt), and glyphosate in combination with two adjuvants (crop oil concentrate or non-ionic surfactant), a DRA (Polyethylene glycol + choline chloride + guar gum blend), and a pH buffer (potassium carbonate). Adding dicamba, glyphosate, or a DRA did not reduce volunteer corn control with clethodim (92 to 95% control). Adding potassium carbonate to clethodim treatments resulted in up to a 94% reduction in corn control. Replacing crop oil concentrate with nonionic surfactant in treatments containing glyphosate resulted in an 88 or 10% reduction in corn control for treatments with or without potassium carbonate, respectively. The second experiment evaluated the effect of dicamba formulations and pH buffer types on the antagonism of clethodim for volunteer corn control. Dicamba formulations included the BAPMA salt of dicamba, DGA salt of dicamba, and the premixture of DGA salt of dicamba + potassium acetate. The pH buffer types included potassium acetate and potassium carbonate. Overall, adding dicamba to clethodim treatments had little to no effect on corn control, regardless of dicamba formulation. Adding potassium acetate to clethodim treatments resulted in a 31 to 44% reduction in corn control. In comparison, adding potassium carbonate to clethodim treatments resulted in a 44 to 70% reduction in corn control. These results suggest that adding a pH buffer to clethodim is the main factor contributing to the antagonism of clethodim for volunteer corn control in dicamba-resistant soybean systems.

Variable-rate Residual Herbicide Application Based on Weed Distribution and Soil Texture (37)

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The ability to use variable rate technology in row crop farming is becoming more popular in the industry. The main benefit of this technique is the ability to maximize the efficiency of inputs and minimize negative effects on the environment. One tactic that requires additional investigation is variable-rate application of residual herbicide applications. The commercialization of John Deere See & Spray technology has made it possible for farmers to acquire ‘weed pressure maps’ that can help them identify areas of the field where greater residual herbicide rates may be beneficial. In addition, many residual herbicides are determined based on the soil texture or organic matter. We hypothesize that variable rate application of residual herbicides will optimize herbicide rates across the field, thereby increasing economic returns. A research study was conducted on a farmer’s field located near Salina, KS during the summer of 2024. Residual herbicide rates included a flat rate and three variable rates determined by: 2023 weed pressure, soil series, and weed pressure plus

soil series. Postemergence herbicide application and yield maps were obtained from the farmer and correlated with residual herbicide application maps. Preliminary results suggest a relationship between residual herbicide application rates and soybean yield.

Evaluation of Post Emergent Herbicide Applications with the DJI Agras T40 in Soybean (38)

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The use of unmanned aerial vehicles (UAV) shows promise as a potential new method of herbicide application, however few studies have been conducted to determine the effects of various UAV application parameters on spray quality, spray deposition, and weed control. Two field experiments were conducted in soybean fields in 2023 and 2024 to: 1) evaluate weed control, spray coverage and uniformity, and off-target movement following herbicide applications from a DJI Agras T40 compared to common commercial ground-based sprayers, and 2) compare the spray deposition of the DJI Agras T40 in a late season soybean canopy to a ground-based sprayer. In the first experiment, post-emergence applications of 2,4-D choline plus pyroxasulfone plus fluthiacet-methyl or acetochlor plus glyphosate or glufosinate were made in four separate soybean fields with either the DJI Agras T40 or a Case IH 3340 Rogator RG900 or John Deere 4830 ground-based sprayer. The DJI Agras T40 was equipped with two centrifugal atomization nozzles set to deliver very coarse or extra coarse droplets at 28 or 47 liters per hectare (lph) while the Case IH 3340, Rogator RG900 and John Deere 4830 ground-based sprayers were set to deliver 140 or 187 lph and were equipped with Wilger MR110-10 combo-jet nozzles, Turbo Twinjet 11005 nozzles, John Deere PSLDMQ2006, and Turbo TeeJet 11005 nozzles. Spray coverage was more than twice as high and off-target movement was less with the ground-based sprayers compared to the DJI Agras T40 UAV. The average spray droplet diameters from the UAV were also substantially smaller than those from the ground-based sprayers and could not be characterized as very coarse or extra course. When evaluating weed control of each system, results from the 2024 field experiments revealed greater levels of weed control from the ground-based sprayers up to 21 days after application. However, weed control was similar between the UAV and the ground-based sprayer applications in the 2023 field experiments. In the second experiment, similar percentages of spray deposition into the soybean canopy occurred between the DJI Agras T40 and the ground-based sprayer. The results from this research indicate that under certain conditions and with specific application settings, similar levels of weed control and spray deposition could be achieved with UAVs compared to ground-based sprayers, however, additional improvements in the sprayer settings are needed to increase droplet sizes, reduce skipped areas that result in weed escapes, and reduce the likelihood of off-target movement.

Foliar-Active Herbicides: Interactions Across Modes of Action (39)

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Herbicide interactions are vital in modern farming, crucial for refining weed management, addressing weed resistance, and ensuring environmentally sustainable and cost-effective approaches. Using a dataset of 16,294 records sourced from 294 publications, we conduct a meta-analysis to examine how foliar-active herbicide interactions respond to various experimental factors. Our study identifies key influencers in herbicide interactions, encompassing experimental methods, target species, herbicide properties, dosage levels, and reveals a temporal trend favoring synergism. These findings illuminate herbicide interaction dynamics, guiding the development of herbicide application rate strategies for target species, while also aiding in the integration of chemical control into site-specific weed management.

Poster Section - Horticulture and Specialty Crops

Reducing the Impact of Dicamba on Tomato (*Solanum lycopersicum*) using Activated Charcoal Coated Fences (40)

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Tomatoes are susceptible to auxin mimic herbicides such as dicamba and 2,4-D, with rates as low as 1/200th of commercial rates resulting in significant injury. The popularity of dicamba- and 2,4-D-tolerant soybeans puts many tomatoes for commercial growers and home gardeners at risk for injury. Activated charcoal, also known as activated carbon (AC), is an amorphous carbonaceous material that traps organic substances in gas or liquid form. Field research was initiated in central Missouri to determine if fencing with different hole openings, coated with AC could minimize off-target injury from dicamba applied to dicamba-tolerant (DT) soybeans adjacent to tomatoes. In late spring, a 61 m row of transplant tomatoes (‘Mountain Fresh Plus’) was established 9 m east from a 0.4 Ha area of DT soybeans. When the prevailing wind was from the west (mid-July), a 2.2 m length of various fencing was erected between the tomatoes and the soybeans and directly adjacent to the tomatoes. The experimental design was a randomized complete block with four replications. Prior to erecting, a fast-drying glue was applied to one side of the fence-pieces, and powdered AC was generously applied immediately to the glue covered surface. The untreated control was chicken wire with no glue. That same day, a tractor-mounted field sprayer was used to apply an approved dicamba formulation at 0.56 kg Ha^{-1} to the soybeans. The hole opening of the fences ranged from construction (large opening) to silt fences (tightly woven). Tomato plant height was measured up to 8 weeks after dicamba treatment, but no treatment differences were detected. In addition, five random leaves representative of new tomato growth were harvested, and the fresh weight of tissue and leaf area index were recorded. Although visual injury from dicamba was evident, no differences in the ratio of leaf area index per gram tissue were evident between AC-coated fences and the untreated control. Additional research with AC is suggested to improve the ability of dicamba in liquid or vapor form to be trapped and protect sensitive crops such as tomatoes.

Evaluating the Crop Response of Fiber Hemp (*Cannabis sativa* L.) to PRE and Early POST Applications of Soil Residual Herbicides (41)

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Weed control is one of the greatest challenges for industrial hemp growers. Only one preemergent (PRE) herbicide, ethalfluralin, is approved for use on hemp in the United States. Additional PRE and postemergent (POST) herbicide options may improve crop management and yields. This study evaluates potential PRE and early-POST herbicides in fiber hemp. PRE and early-POST trials were repeated in Carbondale, Illinois in 2024. Trials were planted on June 13 and July 16. The PRE study was also conducted in New Brunswick, New Jersey, planted on June 26. Studies were randomized complete block designs with four replicates and up to 9 treatments, including a weed-free and a weedy control. The PRE treatments were ethalfluralin (1x=1683.97g ai ha^{-1}), dimethenamid-P (1x=491.08g ai ha^{-1} and 2x=980.73g ai ha^{-1}), linuron (1x=701.15g ai ha^{-1} and 2x=1402.3g ai ha^{-1}), and pyroxasulfone (1x=122.77g ai ha^{-1} and 2x=245.49g ai ha^{-1}). The early-POST treatments were dimethenamid-P (1x=491.08g ai ha^{-1} and 2x=980.73g ai ha^{-1}), linuron (1x=701.15g ai ha^{-1} and 2x=1402.3g ai ha^{-1}), and pyroxasulfone (1x=122.77g ai ha^{-1} and 2x=245.49g ai ha^{-1}), applied at the hemp 4-leaf stage. Data collected were visual hemp injury, visual weed control 7, 14, and 28 days after PRE and POST applications, and end-of-season hemp stand counts and fresh weights. Data were analyzed using one-way ANOVA. Carbondale trials lacked rainfall for incorporation, and weed response was variable; therefore, only crop response is presented. Hemp stand counts were reduced in one of three PRE trials. The first planted PRE trial in Carbondale showed the lowest stand counts in the pyroxasulfone_2x and linuron_2x treatments (28 and 36 plants m^{-2}, respectively). However, this was only statistically different from the weed-free control (80 plants m^{-2}). There were biomass differences by treatment in two of three PRE trials; biomass was lower in pyroxasulfone treatments (1x=1,732g m^{-2}; 2x=1,468g m^{-2}) in the early planted Carbondale trial, which was only different than the weed-free control (3,332g m^{-2}). Biomass in the New Brunswick PRE trial was greater in the linuron treatments (1x=540g m^{-2}; 2x=512g m^{-2}) than in all other treatments except ethalfluralin (384g m^{-2}). Hemp stand counts in the first Carbondale POST trial were lowest in pyroxasulfone_2x (18.8 plants m^{-2}), compared to the weed-free control (80 plants m^{-2}), but was not different than other treatments. Stand counts in the second planting were lowest in the linuron_2x treatments (12 plants m^{-2}) and highest in the pyroxasulfone_1x and weedy control (67 plants m^{-2}) but not different from other treatments, similar to biomass trends in the second POST planting. The PRE trial in New Brunswick suggested that at 14 days after treatment Palmer amaranth (*Amaranthus palmeri* S. Watson) control was greatest in linuron_1x (96%), compared to ethalfluralin (80%) but was not different from other treatments. Large crabgrass (*Digitaria sanguinalis* L.) control efficacy was greatest in the pyroxasulfone_2x treatment (83%) and least in the dimethenamid-P treatment (18%) but not different from other treatments. Results were variable across locations and trial runs; however, data suggest that linuron may control Palmer amaranth and preserve crop yield. Trials will be repeated in 2025.

Evaluation of Jack-o'-Lantern Pumpkin (*Cucurbita pepo* L.) Tolerance to Group 15 Herbicides (42)

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The United States ranks among the top ten pumpkin producers globally, with Indiana as the second leading state and the first in fresh pumpkin production. Weed management in pumpkins relies heavily on pre-emergence herbicides, but options are limited due to potential crop injury. We conducted a field trial in Lafayette, IN in 2024 to evaluate Group 15 herbicides in a conventional tillage system. On June 10, seeds were planted 1.2 m apart in rows 1.8 m apart. Plots consisted of three rows, each 4.88 m long and containing 12 pumpkin plants. Herbicides were broadcast-applied on June 11 with a CO_2-pressurized backpack sprayer calibrated to deliver 187 L ha^{-1} and consisted of two rates each of *S*-metolachlor (1.4 and 2.8 kg ai ha^{-1}), pyroxasulfone (91 and 182 g ha^{-1}), and dimethenamid (239 and 478 g ha^{-1}). Additional treatments included a grower standard (280 g ha^{-1} fomesafen plus 1.1 kg ha^{-1} *S*-metolachlor), a weedy check, and a hand-weeded check. The experiment design was a randomized complete block with four replicates. Data collected at 7, 14, and 28 days after planting (DAP) included plant stand, herbicide injury (0 to 100%), weed control (0 to 100%), weed counts per plot, and yield. Crop injury was $\leq$9% throughout the study. Pooled across both rates of each herbicide, weed control at 14 DAP was 77% for fomesafen plus *S*-metolachlor, 88% for pyroxasulfone, 63% for dimethenamid, and 44% for *S*-metolachlor. The total pumpkin yield of the hand-weeded check was 96,500 kg/ha^{-1} and did not differ from any of the other treatments. In conclusion, this study demonstrates that pyroxasulfone provided comparable weed control to the grower standard and that all treatments in the trial did not result in significant crop injury.

Optimizing Nozzle Selection and Application Techniques for Effective Product Delivery in Hops (43)

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The growing specialty crop industry has increased the demand for locally sourced ingredients, driving the establishment of hop farms across the U.S. Effective weed management within specialty crops that use trellis systems is critical to ensuring high-quality hop yields and minimal interplant competition. However, growers face limited guidance on application parameters suited explicitly for low- and high-trellis systems, including optimal nozzle selection for targeted spray band applications within 91 to 122 cm in a row. This study aimed to evaluate simulated spray pattern deposition within hop plant rows. Using a horizontal spray table, the experiment assessed the spray deposition patterns of two nozzle types (AI8004 and AIUB8504) across three nozzle spacing and boom height configurations (25.4 cm, 50.8 cm, and 76.2 cm) at 276 kPa. As anticipated, results indicated that increasing boom heights and nozzle spacing resulted in broader spray bands. This broadening may lead to reduced dose delivery, potentially contributing to resistance development, or, when used for fertilizer applications, could result in insufficient nutrient delivery. The AI8004 nozzle exhibited inconsistent performance across tested nozzle spacing and boom height configurations. Conversely, the AIUB8504 nozzle demonstrated flexibility, particularly at nozzle spacings and boom heights of 50.8 and 76.2 cm, effectively maintaining the targeted spray bands of 91 to 122 cm in a row. This research underscores the critical role of nozzle selection and configuration in optimizing spray applications. Findings may contribute to developing practical guidelines for herbicide applications, presumably in all trellis-based cropping systems, supporting growers in optimizing weed control while preserving crop health.

Herbicide Impregnated Fertilizer for Increased Pumpkin Crop Safety (44)

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Few herbicides are registered for use in pumpkins (*Cucurbita pepo*), due in part to their potential for causing crop injury and reducing yield. However, changes to herbicide application methods may reduce crop injury and allow previously unusable herbicides to become registered. In 2024, a field study was conducted at the Throckmorton Purdue Agriculture Center in Lafayette, IN to determine jack-o'-lantern pumpkin tolerance to herbicides broadcast-applied on impregnated fertilizer. 'Bayhorse Gold' pumpkin seeds were planted on June 7 0.91 m apart in rows 1.83 m apart. Plots consisted of three rows, each 4.88 m long resulting in 12 pumpkin plants per plot. Immediately after planting, the entire field was treated with a mixture of 1191 g ai ha^{-1} *S*-metolachlor and 420 g ai ha^{-1} fomesafen. Impregnated fertilizer treatments consisted of flumioxazin (87.57 and 175. 14 g ai ha^{-1}), dimethenamid-P (840.64 and 1681.28 g ha^{-1}), pyroxasulfone (91.29 and 182.58 g ha^{-1}) and glyphosate (770.58 g ae ha^{-1}) applied 14 or 21 days after planting (DAP). Additional treatments included sprayed applications of each herbicide at their lowest rate 14 DAP as well as hand-weeded and weedy controls. The impregnated fertilizer was created by combining 35.6 ml of solution (1 ml of blue indicator dye, herbicide, and water) with 3,590 g 21% nitrogen spray grade AMS in a bucket. The impregnated fertilizer was then spread out onto plastic tarps and dried for 2 hours before being applied at a rate of 899 g per plot. Spray applications were made with a CO_2-pressurized backpack sprayer calibrated to deliver 187.08 l ai ha^{-1} at 207.84 kPa. The experiment design was a randomized complete block with 4 replicates. Data collection included crop stand and injury (0 to 100%), weed counts, and pumpkin yield. Some notable stats, data collected 49 DAP found that flumioxazin treatment 87.57g ai ha^{-1} for 21 DAP fertilizer averaged 21.25% herbicide damage, 3.5 grasses, and 6 broadleaves per plot as opposed to 87.57 g ai ha^{-1} for 14 DAP spray treatment, which averaged 75% herbicide damage, 1 grass and 0 broadleaves. The glyphosate 770.58 g ai ha^{-1} 14 DAP fertilizer treatment averaged 22.5% herbicide damage, 0.75 grasses, 21.5 broadleaves, and glyphosate 770.58 g ai ha^{-1} 14 DAP spray averaged 93.75% herbicide damage, 0.75 grasses, and 42.5 broadleaves. During harvest, flumioxazin 87.57g ai ha^{-1} for 21 DAP fertilizer grew 70 orange pumpkins averaging 7.16 g per pumpkin, dimethenamid-P 1681.28 g ha^{-1} 21 DAP fertilizer grew 91 orange pumpkins averaging 6.52 g, glyphosate 770.58 g ae ha^{-1} 21 DAP fertilizer grew 85 pumpkins averaging 6.3 g per pumpkin, and pyroxasulfone 91.29 g ai ha^{-1} 14 DAP fertilizer grew 76 pumpkins averaging 6.21 g. This is compared to the weed-free control which grew 103 pumpkins averaging 6.12g.

Poster Section - Range, Pasture, and Vegetation Management

Propane Flaming as a Non-chemical Tool for Alfalfa Weevil Control (45)

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Alfalfa weevil can significantly decrease both the quality and yield of alfalfa crops. Insecticides, while effective, may harm beneficial insects and are not suitable for organic agriculture. Therefore, an effective non-chemical control method is needed. This study investigated propane flaming as a potential solution. Field studies were conducted on an organic farm near Abie, Nebraska in 2022 and 2023, 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, on a scale 0-100%, was 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 m^2 at 8 cm alfalfa height, 10 to 19 per m^2 at 15 cm height, and 2 to 5 per m^2 at 30 cm height. The number of adult weevils ranged from 0 per m^2 in plots flamed with 43 to 85 kg ha^{-1}, to 1.5 per m^2 in plots flamed with 28 kg ha^{-1}, and up to 5 per m^2 in the non-flamed control plots at 8 cm and 15 cm alfalfa heights. Number of weevils 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. Results suggest that propane flaming can effectively control alfalfa weevil and reduce feeding injury, making it a promising non-chemical control method suitable for organic systems. This approach could be further integrated with propane flaming for weed control (recommended rate is about 60 kg ha^{-1}), offering a dual-purpose strategy that addresses both weed and insect management in alfalfa crops, thereby enhancing the sustainability and efficiency of organic farming systems.

Comparison of Electrocution with Common Herbicide Treatments for Weed and Tall Fescue Seedhead Management in Missouri Pastures (46)

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Electrocution has been shown to provide effective weed control in soybean [*Glycine max* (L.) Merr.] and sugar beet [*Beta vulgaris* (L.)] production. Despite its efficacy, little research has been conducted to evaluate the potential for electrocution to control common weeds in pastures. Electrocution could additionally be utilized as a management tool to minimize the production of tall fescue [*Schedonorus arundinaceus* (Schreb.)]) seedheads. Cattle that graze tall fescue that have produced seedheads that are infected with an endophyte have the potential to develop fescue toxicosis, which can lead to reduced conception rates, reductions in weight gain, milk production, and elevated body temperature. Two separate experiments were conducted in Missouri in 2023 and 2024 to: 1) evaluate the effectiveness of electrocution on tall fescue seedhead management, and 2) evaluate forage injury and weed control following electrocution in comparison to common pre-packaged pasture herbicide combinations in mixed tall fescue legume pastures. In the first experiment, electrocution was conducted using the Weed Zapper™ between April 19 and May 4 on actively growing tall fescue plants. Metsulfuron-containing herbicides commonly utilized for tall fescue seedhead reduction were applied at the same time for comparison. Sequential electrocution passes spaced two-weeks apart provided similar reductions in tall fescue seedheads as metsulfuron-containing herbicides when applied at the boot-stage. Additionally, sequential same day electrocution passes or sequential passes spaced two weeks apart resulted in similar reductions in tall fescue forage yield as metsulfuron-containing herbicide treatments. In the second experiment, electrocution was compared to herbicide application in seven mixed tall fescue and legume pastures in Missouri in 2023 and 2024. All weed management treatments occurred between July 30 and September 1, during the semi-dormant period of tall fescue growth when weed pressure is often highest. Overall, sequential passes of electrocution spaced two weeks apart provided greater weed control than either one- or two-passes of electrocution on the same day. Many pre-packaged herbicide combinations eliminated white clover (*Trifolium repens*) whereas electrocution had minimal effects on this species. Results from these experiments indicate that electrocution can provide similar control of certain weed species as common pasture herbicide mixtures without significantly impacting forage yield or causing legume injury.

Some Early Pollinator Plot Establishment Herbicide Options (47)

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Successfully establishing and maintaining primarily perennial plant pollinator / wildflower plots is a challenge. Annual weedy grasses, such as giant foxtail (*Setaria faberi* Herrm.) and yellow foxtail (*Setaria pumila* (Poir.) Roem. & Schult.), can become dominant in newly planted pollinator plots, especially if they're planted in the spring without sufficient site preparation. One of the challenges when selecting herbicide options is the combination of desirable monocot (i.e. grasses) and dicot (i.e. broadleaf plant) species within the seed mixture.

Winter annuals such as common chickweed (*Stellaria media*) and purple dead-nettle (*Lamium purpureum)* can carpet a recently planted site. Do these winter annual weeds have a detrimental effect on the pollinator planting in the near and long term? What effect(s) would early spring management options have on the planting?

This trial was established at a pollinator planting along US68 near Maysville, KY. The site was prepared with three applications of herbicides (broadcast and/or spot applied) in 2020 and 2021 with the last application on 9/10/2021. The seed mix was drilled on 10/5/2021.
The herbicide treatments included Plateau (imazapic) @ 70 g ae ha^{-1}, Pendulum AquaCap (pendimethalin) @ 2.1 kg ha^{-1}, Dual II Magnum (S-metolachlor) @ 1.4 kg ha^{-1}, Reward (diquat) @ 280 g ha^{-1}, and Finale (glufosinate) @ 2 kg ha^{-1} by themselves. Plateau, Reward, and Finale were also applied in combination with Pendulum AquaCap.

The trial was sprayed April 22, 2022. The trial had 9 treatments with 3 replications arranged in a randomized complete block design with 3 m by 9.1 m plots. Application was at 234 L ha $^{-1}$. The common chickweed and purple dead-nettle plants were 15 cm tall and flowering at time of application. The coreopsis (*Coreopsis lancelata* L.) plants were 20 cm, wild garlic (*Allium ursinum*) was 38 cm, and the oats (*Avena sativa)* were 30 cm tall. The Williamstown weather station reported 1.5 cm of precipitation between 4/22 and 4/27 which should have been enough to activate the pre emerge products.

Chickweed control and oat and coreopsis / cornflower (*Papaver rhoeas)* damage were assessed 6 (4/28/2022) days after treatment (DAT). The oat stand (% of full) and % ground cover of different components of the canopy were visually assessed 53 DAT (6/14/2022). The proportion of bare ground and cover from different species were assessed 103 (8/3/2022) and 159 (9/28/2022) DAT. Data were analyzed using ARM software and treatment means were compared using Fisher's LSD at p = 0.05.

The different herbicide treatments affected the establishment and progression of pollinator plants compared to the nontreated control. Lower rates of Reward and Finale may have resulted in good control of common chickweed and purple dead nettle with less damage on other emerged plants. Leaving them alone early in the establishment year is likely the best management strategy.

Poster Section - Row Crop Herbicide Management

Can Metribuzin Enhance the Response of Carryover Injury from Mesotrione in Soybeans (48)

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In Midwest crop production systems, the rotation of corn (*Zea mays* L.) and soybean (*Glycine max* (L.) Merr.) can lead to challenges with herbicide carryover, especially in dry conditions. Late applications of mesotrione in corn are particularly of concern, and the possible interaction between mesotrione carryover and commonly applied preemergence soybean herbicides such as metribuzin. Soybean varieties exhibit varying tolerance levels to metribuzin, with some highly sensitive and others more tolerant. Our research objectives were to determine: 1) if carryover injury on soybean from mesotrione could be exacerbated by the use of metribuzin as a preemergence application, and 2) if differential soybean sensitivity to metribuzin influences the expression of soybean injury from the herbicide interaction. A field trial was conducted as a randomized complete block design with four replications and three factors: soybean cultivar (metribuzin sensitive and tolerant), metribuzin rate, mesotrione rate. Treatments included mesotrione (26.25 and 52.5 g ai ha^{-1}), metribuzin (210, 420, 630, and 840 g ai ha^{-1}), and combinations of mesotrione plus metribuzin. Herbicides applied immediately after soybean planting using a 2 m handheld boom calibrated for a spray volume of 140 L ha^{-1} at 172 kPa. Visual assessments of crop injury were conducted at 14, 21, and 28 days after application (DAA), accompanied by RGB drone imagery. Data were analyzed using R Studio, employing analysis of variance and Tukey's Honest Significant Difference test at an alpha level of 0.05. Colby's method was utilized to assess interactions between the herbicides based on visual ratings. Pix4D, an imaging software, was used to analyze canopy coverage. The interaction of metribuzin and mesotrione for soybean injury was not influenced by soybean variety, but was dependent on the rate of metribuzin. At 21 DAA, visual crop injury was 10% for mesotrione (52.5 g ha^{-1}), 3% for metribuzin (420 g ha^{-1}), and 18% for the synergistic combination of the mesotrione and metribuzin at these use rates. The low and high rates of metribuzin (210 and 840 g ha^{-1}) applied with mesotrione resulted in additive soybean responses. A synergistic interaction was observed with RGB drone images in Pix4D with mesotrione (52.5 g ai ha^{-1}) plus metribuzin (420 and 630 g ai ha^{-1}) at 14 and 21 DAA. This research indicates that there are additive and synergistic responses for soybean between simulated carryover rates of mesotrione and metribuzin. This research will be repeated in 2025 and validated in a controlled environment chamber experiment.

Evaluating Overlapping Residual Herbicide Programs for Weed Management in Soybean (49)

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Herbicide-resistant Palmer amaranth poses a significant challenge for soybean production in the United States due to its wide emergence window. Effective season-long management strategies are needed to combat Palmer amaranth. This study was conducted to evaluate various overlapping residual herbicide programs for season-long Palmer amaranth control in soybean. The experiment followed a split-plot design with three replications at the South-Central Ag Lab in Harvard, NE. The experimental site was sprinkler irrigated with silt loam soil. The main plot factor included two pre-emergence (PRE) herbicide treatments: (i) flumioxazin (87 g ai ha^{-1}) + metribuzin (140 g ai ha^{-1}) + pyroxasulfone (111 g ai ha^{-1}), and (ii) flumioxazin (108 g ai ha^{-1}). The subplot factor consisted of nine combinations of early post-emergence (EPOST) and late post-emergence (LPOST) herbicides: (i) untreated, (ii) Perpetuo low [flumiclorac (31 g ai ha^{-1}) + pyroxasulfone (90 g ai ha^{-1})] EPOST, (iii) Perpetuo high [flumiclorac (52 g ai ha^{-1}) + pyroxasulfone (150 g ai ha^{-1})] EPOST, (iv) Perpetuo low EPOST followed by (fb) acetochlor (1,048 g ai ha^{-1}) LPOST, (v) Perpetuo high EPOST fb acetochlor (1,467 g ai ha^{-1}) LPOST, (vi) Perpetuo low EPOST fb acetochlor (1,048 g ai ha^{-1}) LPOST, (vii) Perpetuo high EPOST fb acetochlor (1,467 g ai ha^{-1}) LPOST, (viii) Perpetuo low EPOST fb acetochlor (1,184 g ai ha^{-1}) + fomesafen (263 g ai ha^{-1}) LPOST, (ix) Perpetuo high EPOST fb acetochlor (1,184 g ai ha^{-1}) + fomesafen (263 g ai ha^{-1}) LPOST. At 28 days after the LPOST application, the flumioxazin PRE followed by untreated control resulted in the lowest Palmer amaranth control (55%), followed by flumioxazin PRE fb Perpetuo low EPOST (82%). All other treatments achieved over 95% control and were statistically similar. Similar results were observed 56 days after LPOST application. Flumioxazin PRE fb untreated treatment (25%) had the lowest Palmer amaranth control followed by flumioxazin PRE fb Perpetuo low EPOST (65%) and flumioxazin PRE fb Perpetuo high EPOST (75%). Other treatments had more than 95% Palmer amaranth control at 56 days after LPOST application. Soybean yields across treatments ranged from 3,944 to 5,801 kg ha^{-1}, but the differences were not statistically significant. However, plots treated solely with flumioxazin PRE had higher Palmer amaranth densities, leading to seed production and potential future infestations. These results emphasize the importance of utilizing overlapping residual herbicide programs for effective season-long Palmer amaranth control. Relying solely on a PRE herbicide, such as flumioxazin, is not recommended, as it may result in inadequate control and contribute to future weed problems.

Overcoming ACCase Inhibitor Antagonism with 2,4-D for Controlling Glyphosate-Resistant Volunteer Corn in Enlist Soybean (50)

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Glyphosate-resistant volunteer corn (*Zea mays* L.) has become a problem weed in soybean fields when rotated with corn in the Midwestern United States. With the widespread adoption of Enlist E3® soybean (tolerant to 2,4-D choline/glyphosate/glufosinate) in this region, farmers have reported difficulty controlling glyphosate-resistant volunteer corn when ACCase inhibiting herbicides (WSSA site of action group 1) were tank mixed with 2,4-D (group 4). Field experiments were conducted in a randomized complete block design with four replications at Rochester and Waseca, MN in 2022 and 2023. The objective was to evaluate the interaction between ACCase-inhibiting herbicides (clethodim and quizalofop-ethyl) and 2,4-D choline-alone or 2,4-D choline tank-mixes with glyphosate and/or *S*-metolachlor for glyphosate-resistant volunteer corn control in Enlist E3® soybean. In Rochester, the higher dose of ACCase herbicides, clethodim or quizalofop-ethyl plus 2,4-D provided ≥ 93% volunteer corn control irrespective of the addition of glyphosate or *S*-metolachlor at 28 days after treatment (DAT). The lower dose of clethodim plus 2,4-D plus glyphosate with or without *S*-metolachlor provided 78 to 86% control, which was similar to clethodim plus 2,4-D at that time. However, quizalofop-ethyl at a lower dose tank mixed with 2,4-D irrespective of glyphosate or *S*-metolachlor addition resulted in 29 to 49% control. In Waseca, all clethodim-based tank mixtures resulted in ≥ 93% volunteer corn control at 28 DAT except for 2,4-D plus glyphosate plus clethodim at a lower dose with or without *S*-metolachlor. The 2,4-D plus quizalofop-ethyl at higher dose plus *S*-metolachlor with or without glyphosate provided 86% control, however, the lower rate of quizalofop-ethyl with or without *S*-metolachlor or glyphosate resulted in only 14 to 26% control. 2,4-D choline plus clethodim at higher dose with or without *S*-metolachlor or glyphosate resulted in similar yield as weed free treatment across both locations. The results indicated that antagonism between 2,4-D choline and ACCase inhibitors can be mitigated by increasing the rates of ACCase inhibitors. Additionally, adding glyphosate and *S*-metolachlor to the tank mix did not affect the performance of these combinations.

Wisconsin Waterhemp Herbicide Resistance Monitoring: What has Changed in 5 Years? (51)

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Waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer), a highly competitive weed, poses a substantial challenge to corn and soybean production systems in the U.S. Midwest. It is a prolific seed producer, and its ability for both intraspecific and interspecific cross-pollination, combined with effective seed dispersal, significantly enhances its adaptability and persistence across agricultural landscapes. These mechanisms enhance the spread of resistance traits among populations, complicating management strategies. In Wisconsin, waterhemp has evolved resistance to multiple commonly used herbicide modes of action such as ALS- EPSPS-inhibitors, undermining the effectiveness of herbicide treatments. To assess changes in herbicide resistance over the past five years, greenhouse experiments were conducted using 26 accessions of waterhemp collected in 2023 from a statewide collection, with results compared to our previous screening efforts conducted on 26 accessions collected in the fall of 2018. This study evaluated the response of waterhemp to now commonly used POST (2,4-D, atrazine, dicamba, glufosinate, fomesafen, and mesotrione, applied at 1X and 3X the labeled rates) herbicides in corn and soybean production to manage ALS- and EPSPS-resistant weeds. The herbicide treatments remained consistent compared to our previous screening efforts conducted on 26 accessions collected in the fall of 2018. Major differences in survival (%) and biomass reduction (%) were observed between accessions collected in 2018 and 2023 when exposed to 2,4-D, atrazine, dicamba, fomesafen, and mesotrione. No changes were observed in waterhemp survival and biomass reduction with glufosinate at either herbicide dose across accessions. The results indicated an increase in waterhemp survivorship (%) among accessions collected in 2023 at the 1X dose of 2,4-D, atrazine, dicamba, fomesafen, and mesotrione, with survival rates rising from 11%, 11%, 8%, 3%, and 3%

to 52%, 81%, 49%, 21%, and 11%, respectively, compared to accessions collected in 2018. At the 3X dose of 2,4-D, atrazine, dicamba, fomesafen, and mesotrione, waterhemp survivorship rates among accessions collected in 2023 increased from 3%, 7%, 3%, 2%, and 2% to 22%, 41%, 7%, 8%, and 4%, respectively, compared to accessions collected in 2018. A decrease in waterhemp biomass reduction (%) among accessions collected in 2023 was observed with the application of a 1X dose of 2,4-D, atrazine, dicamba, and fomesafen, compared to accessions collected in 2018. Although biomass reduction >92% across all accessions at the 1X dose of 2,4-D, dicamba, and fomesafen for both 2018 and 2023 accessions, waterhemp biomass reduction at the 1X dose of atrazine decreased from 94% to 77%. At the 3X dose of herbicides, biomass reduction differences were observed only for 2,4-D and atrazine, though biomass reduction >89% across all accessions. Although the waterhemp accessions collected in 2023 were not in the exact same location as those in 2018, the survivorship status of waterhemp has changed over the past five years for the herbicides 2,4-D, atrazine, dicamba, fomesafen, and mesotrione. These findings highlight the importance of continuous monitoring and the urgent need for alternative weed management strategies, along with adaptive management approaches to effectively combat herbicide-resistant waterhemp populations.

Wheat Seed Germination Following Pre-Harvest Herbicide Application (52)

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Weeds growing in wheat (*Triticum aestivum L.*) fields at harvest time are very problematic for farmers. Although there are some herbicides labeled for pre-harvest applications in wheat, the label language is limited to confidently predicting how these herbicide applications will affect the germination of wheat saved for seed. Therefore, this study investigated the effects of pre-harvest herbicide applications on wheat seed germination to provide this clarification. The main objective was to evaluate five different herbicides and their possible effects on wheat seed viability and quality. The study was conducted in a greenhouse located in Manhattan, KS and two fields, one near Manhattan, KS, and one near McPherson, KS. Saflufenacil (0.025 and 0.05 kg ai ha^{-1}), flumioxazin (0.052 and 0.07 kg ai ha^{-1}), 2,4-D (0.53 kg ai ha^{-1}), dicamba (0.28 kg ai ha^{-1}), and carfentrazone (0.035 kg ai ha^{-1}) were applied to two wheat varieties (KSU Providence and KSU Hamilton). In the greenhouse, herbicides were applied at the soft dough and hard dough stages of wheat development. Applications were made only at hard dough for field experiments. Crop injury was evaluated three and seven days after application. Wheat seed germination and vigor were assessed after wheat harvest. Crop injury was observed following flumioxazin application at soft and hard dough. Initial results from the greenhouse trial suggest that germination was influenced by variety more than herbicide or application timing. KSU Providence germination was negatively affected by saflufenacil applied to a soft dough and flumioxazin applied at hard dough, but KSU Hamilton germination was not affected by any of the treatments evaluated.

Managing Corn Volunteers in Herbicide-resistant Sorghum (53)

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Volunteer corn can be a problematic weed in corn-based rotations. It is challenging to control, especially in grass row crops. Quizalofop-resistant (DoubleTeam) sorghum has been commercialized recently, which allows the use of quizalofop (FirstAct) to control grass weeds. Field experiments were conducted near Clay Center, NE, in 2023-24 to evaluate quizalofop for the control of glufosinate/glyphosate-resistant volunteer corn in quizalofop-resistant sorghum. The early-POST application of quizalofop 73 g ha^{-1} controlled 96% to 99% of volunteer corn 14 DAT and 98% to 99% 28 DAT. The late-POST application of quizalofop 73 g ha^{-1} provided 83% to 99% control 14 DAT and 96% to 99% control 28 DAT. It is concluded that both early-POST and late-POST applications of quizalofop effectively controlled glufosinate/glyphosate-resistant volunteer corn in quizalofop-resistant sorghum.

Residual Control of Broadleaf Weeds with Encapsulated Saflufenacil + Pyroxasulfone in Corn (54)

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The protoporphyrinogen oxidase (PPO)-inhibiting herbicide saflufenacil is commonly used in burndown and preemergence herbicide applications to control broadleaf weeds in corn. However, the foliar activity of saflufenacil restricts applications to prior to corn emergence. A microencapsulated saflufenacil formulation has been developed to increase the crop safety of saflufenacil in postemergence corn applications by limiting foliar absorption of saflufenacil. Encapsulated saflufenacil is formulated in a premixture with the very long-chain fatty acid (VLCFA)-inhibiting herbicide pyroxasulfone and is labeled for preemergence through V3 application in corn. In 2023 and 2024, a field experiment was conducted to evaluate the residual broadleaf weed control of preemergence (PRE) and PRE followed by early postemergence (EPOST) applications of the encapsulated saflufenacil + pyroxasulfone premixture and an unencapsulated mixture of these herbicides in comparison to commercial standard residual corn herbicide programs. Herbicide applications were performed with a 2 m handheld boom calibrated to deliver 140 L ha^{-1} at 172 kPa. There were no differences in giant ragweed (*Ambrosia trifida* L.) control at 28 DAA between the low rate of unencapsulated saflufenacil applied with pyroxasulfone and the low rate of encapsulated saflufenacil + pyroxasulfone. The high rate of unencapsulated saflufenacil applied in combination with pyroxasulfone resulted in 95% giant ragweed control 28 DAA, compared to only 74% control for the high rate of the encapsulated saflufenacil + pyroxasulfone premixture. When encapsulated saflufenacil + pyroxasulfone was applied with atrazine, giant ragweed control was similar to the commercial standards (saflufenacil + dimethenamid-P, atrazine + bicyclopyrone + mesotrione + s-metolachlor, atrazine + s-metolachlor, isoxaflutole + thiencarbazone-methyl + flufenacet, s-metolachlor + mesotrione + pyroxasulfone + bicyclopyrone) at 28 and 42 DAA. Similarly, at 42 DAA the encapsulated saflufenacil + pyroxasulfone overlapping residual program resulted in greater than 95% giant ragweed control which was comparable to atrazine + bicyclopyrone + mesotrione + s-metolachlor and the atrazine + s-metolachlor. Additionally, the encapsulated saflufenacil + pyroxasulfone premixture resulted in greater than 90% control of waterhemp (*Amaranthus tuberculatus* (L.) Merr) and common lambsquarters (*Chenopodium album* L.) at 28 and 42 DAA. However, the lack of rainfall immediately after application likely limited giant ragweed control as saflufenacil was not activated. In our research, less than 11 mm of rainfall was received within 7 days of the PRE application in both years. This is less than the 13 mm necessary for saflufenacil activation as outlined by the product label for the encapsulated saflufenacil + pyroxasulfone premixture. These results indicate that the encapsulated saflufenacil + pyroxasulfone premixture does control small-seeded broadleaf weeds (waterhemp and common lambsquarters) similar to commercially available corn herbicides, which can be attributed to the pyroxasulfone component of the premixture. However, giant ragweed control was dependent on available saflufenacil in the soil solution and was limited likely due to the lack of rainfall required to move saflufenacil out of the encapsulation.

Integrated Management of Key Pests in Corn-Potato Systems (55)

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Volunteer potatoes (*Solanum tuberosum*) are potatoes left in the field after harvest that can overwinter and emerge the following spring. This weed can cause significant yield loss in rotational crops and is an early season food source for Colorado Potato Beetle *(Leptinotarsa decemlineata*, CPB) which is the most important insect defoliator of potatoes. The main objectives of this research were to provide insight into the volunteer potato-CPB complex and evaluate integrated management strategies of these key pests in corn. To address these objectives, field and greenhouse trials were conducted in Michigan in 2023 and 2024. Experiment 1 was conducted at the Montcalm Research Center (MRC), Kellog Biological Station (KBS), and Michigan State University (MSU). Experiment 2 was conducted at the Montcalm Research Center. Experiments followed a split-plot randomized complete block design with four replications. Potatoes were spread to simulate volunteers, followed by the application of tillage treatments including light intensity (disk) and aggressive intensity (moldboard plow). In experiment 1, potatoes were spread in the fall of 2023 and in experiment 2 potatoes were spread in the spring of 2023 and 2024. Corn was planted each spring. Subplot factors included combinations of tank-mixed herbicides and insecticides applied at two timings based on volunteer height (less than 15 cm vs. greater than 15 cm). Herbicide treatments included mesotrione or topramezone and insecticide treatments included spinetoram or chlorantraniliprole. Volunteer emergence was assessed prior to the first application timing. Corn injury and volunteer control were evaluated at 7, 14, and 21 days after application (DAA). CPB number and defoliation was evaluated on volunteer subsamples at 2, 4, and 6 weeks after application. Tuber production was measured at the end of the season. Experiment 3 was conducted in greenhouses at MSU. Subplot factors were the same as in field experiments, applied alone and in each tank-mix combination to corn at growth stages V1, V2, V3 and V4. Injury was evaluated at 3, 7, and 14 DAA and biomass collected 14 DAA. Data was analyzed in R using linear mixed effects models and means separated using Tukey's HSD at $\alpha \leq 0.05$. When volunteers were spread in the fall, emergence was higher in the plow system at KBS and MSU ($p<0.0001$). When volunteers were spread in the spring, emergence was higher in the disk system in 2024 ($p<0.0001$). In experiments 1 and 2, corn injury was less than 5% across all treatments and did not impact

development. At KBS, the highest beetle population was observed on untreated plants in the plow system resulting in 92% defoliation (p=0.04). All herbicide-insecticide mixes reduced the number and weight of daughter tubers per plant relative to untreated controls (p<0.05). In the plow system, treatments including mesotrione were the most effective, reducing daughter tuber weight by 82% compared to untreated plants (p=0.003). Experiment 3 resulted in no visible injury symptoms or significant differences in biomass within each corn stage, further indicating the safety of these tank-mixes (p>0.05). These integrated approaches can be used to reduce volunteer emergence and manage both pests.

Efficacy of Common Corn Herbicide Programs in Nebraska (56)

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Corn herbicide programs are important in an integrated weed management system for hard to control herbicide resistant species such as common waterhemp (Amaranthus x tamariscinus Nuttall). Efficacious herbicide programs are important in crop production. Herbicide rate and timing choices can affect overall weed control. To help in herbicide recommendations for extension activities, several current and new corn herbicides were evaluated at the Eastern Nebraska Research Extension and Education Center (ENREEC) near Mead, NE. Standard small research plot techniques were used in this study. Several corn herbicide combination premixes {[S-metolachlor+ atrazine+ mesotrione+ bicyclopyrone] 2892 g ha^{-1}; [mesotrione+ clopyralid+ pyroxasulfone] 621.7 g ha^{-1}; [acetochlor+ mesotrione+ clopyralid] 2740 g ha^{-1}; and [S-metolachlor+ mesotrione+ pyroxasulfone+ bicyclopyrone] 2169 g ha^{-1}} at full label rates applied PRE performed excellent in moderate weed infestations. At higher weed infestations performance was reduced in a one pass situation. A POST application with a non-selective and a residual herbicide maintained season long weed control.

Pre-emergence Tank-Mixes for Waterhemp (*Amaranthus tuberculatus*) Control in HT4 Soybean (57)

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Waterhemp (*Amaranthus tuberculatus*) is a problematic weed in many soybean (*Glycine max*) 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, Bayer is developing HT4 soybean, with a target launch date of 2027. These soybean lines 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 the HT4 soybean system. Two bare-ground field trials were conducted in 2024 in Glyndon, Minnesota (sandy loam soil with 2.8% OM and a pH of 8.2) and Fargo, North Dakota (silty clay soil with 5.7% OM and pH of 7.1) to evaluate preemergence tank-mixes on waterhemp control. Of note, both locations received over 15 cm of precipitation within the first 21 days after trial initiation. Trials were a randomized complete block design with 4 replications. Treatments were arranged in a factorial structure, with 4 different herbicides applied at either a 0X or 1X rate for this geography, resulting in 16 different treatment combinations. Herbicides evaluated were dicamba at 560 g ae ha^{-1}, mesotrione at 105 g ai ha^{-1}, metribuzin at 280 g ai ha^{-1}, and encapsulated-acetochlor at 1260 g ai ha^{-1}. Weed control was assessed at 14, 28, 42, and 56 days after treatment (DAT) using visual control ratings, with a scale of 0 to 100 (0 representing no control and 100 representing complete plant death). Waterhemp density was measured within 2, $0.5m^2$ quadrats at 28 and 56 DAT, and biomass collected at 56 DAT. Data were analyzed using ANOVA, and treatment separation analyzed with Fisher's protected LSD with α=0.05. Along with the abnormally high precipitation, temperatures in May and June were below average, resulting in delayed waterhemp emergence at both locations. Treatments with encapsulated-acetochlor alone or tank-mixes that contained encapsulated-acetochlor all provided the greatest waterhemp control at both locations. At Glyndon, no treatments reduced waterhemp density compared to the non-treated check at the final evaluation. However, all treatments containing encapsulated-acetochlor reduced waterhemp biomass, compared to the check. All treatments without encapsulated-acetochlor had the same biomass as the check. These results indicated that encapsulated-acetochlor provided residual control through most of the experiment, but a late waterhemp flush resulted in similar densities to the check. The Fargo location was under standing water for up to 3 weeks, which resulted in more variable waterhemp densities and biomass by the last evaluation timing. These trials will be repeated in 2025, and further research will be conducted in the greenhouse utilizing these same soils under different precipitation regimes.

Enhancing Palmer Amaranth (*Amaranthus palmeri*) Control in Soyabean: Effective Strategies for Glufosinate and 2,4-D Applications (58)

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Palmer amaranth (*Amaranthus palmeri)* is one of the most troublesome weed species in the United States. It has evolved resistance to multiple herbicide sites of action, posing significant challenge to crop yields. Effective management strategies are crucial to mitigate the negative effects of Palmer amaranth on soybean production, especially for large weeds during late summer. This study was conducted during the summer of 2024 near Manhattan, Kansas to evaluate the effectiveness of herbicide combinations and application intervals for controlling Palmer amaranth in late-planted soybeans. Initial applications were applied when Palmer amaranth was approximately 20 to 30 cm tall and included two herbicide treatments: glufosinate with or without 2,4-D choline. Sequential applications of glufosinate or glufosinate + 2,4-D choline were applied 3, 10, or 14 days after the initial application (DAA). *S*-metolachlor was applied to all plots at soybean planting and was more effective than expected. Visual ratings of weed control were recorded 3, 17, and 73 DAA. At soybean harvest, visible weed control, weed counts, weed biomass, and soybean yield were collected. Data were subjected to analysis of variance and means were separated using Tukey's HSD when appropriate. Palmer amaranth control 3 DAA (before any sequential applications) was 41 % by glufosinate alone and 48% by glufosinate + 2,4-D choline; however, the results were statistically similar. By 73 DAA (70, 60, and 56 days after the sequential applications), Palmer amaranth control was 95% or greater for all treatments that received a second application and 92% for the treatments that received only first application. Palmer amaranth biomass at harvest and soybean yield was similar for all treatments. Notably, there was no significant difference between the treatments that included one or two applications, nor between the glufosinate and glufosinate + 2,4-D choline treatments. These findings suggest that when the PRE herbicides are effective, the choice and timing of subsequent post-emergence applications becomes more flexible. This flexibility allows farmers to adapt their herbicide application regimens based on various factors such as weather conditions and crop growth stages. This research will be repeated during 2025.

Metribuzin and Sulfentrazone Rate and Combination Effects on Weed Control and Crop Safety in Soybean (59)

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Weeds resistant to postemergence soybean herbicides are increasing across North Dakota, which is leading to increased interest in utilizing preemergence herbicides for their control. However, there are concerns about weed control and crop injury from many growers across the many different soils in 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 2 different soybean varieties across 3 unique soil types. Field experiments were conducted in Fargo, ND (silty clay soil with 5.7% OM and pH of 7.1), Hillsboro, ND (sandy loam soil with 4.6% OM and a pH of 7.1), and Glyndon, Minnesota (sandy loam soil with 2.8% OM and a pH of 8.2). 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 taken 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, visual 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*) densities were taken with 2 separate $0.5m^2$ quadrats 28 and 42 DAT with a biomass collection at 42 DAT. At Glyndon, soybean injury persisted across all evaluation timings from metribuzin at 560 g ai ha and the tank-mix of metribuzin at 560 g ai ha^{-1} plus sulfentrazone at 280 g ai ha^{-1}. No visible injury was observed at the other two sites. Across all sites, there were no differences in yield. Both the Fargo and Glyndon locations received over 15 cm of precipitation within 21 days after planting. There were no differences in herbicide treatments on weed control at Glyndon. At Fargo, at 28 DAT all treatments reduced waterhemp density compared to the check but were not different from each other. At 42 DAT, metribuzin at 280 g ai ha^{-1} reduced waterhemp by 67% compared to check, while all other treatments further reduced density. All treatments except metribuzin at 280 g ai ha^{-1} reduced waterhemp biomass compared to the check. These experiments will be conducted again in 2025, and further research will include greenhouse experiments to evaluate these treatments on the same soils under controlled amounts of precipitation.

Wisconsin Waterhemp Herbicide Resistance Monitoring: Where Are We At? (60)

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Waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer), a highly competitive weed, presents a significant challenge to corn and soybean production systems across the U.S. Midwest. In Wisconsin, waterhemp has developed resistance to multiple herbicide modes of action, undermining the effectiveness of chemical weed control. This greenhouse study evaluated the efficacy of commonly used post-emergence (POST) and pre-emergence (PRE) herbicides in controlling waterhemp accessions collected in the fall of 2023 from various agricultural fields across Wisconsin. Greenhouse experiments were conducted using 26 accessions, with POST treatments including 2,4-D, atrazine, dicamba, glufosinate, fomesafen, and mesotrione, and PRE treatments consisting of atrazine, fomesafen, mesotrione, metribuzin, and S-metolachlor, applied at 0.5×, 1× and 3× the labeled rates. At the 0.5× application rate, all accessions exhibited ≥50% survivorship for atrazine, 2,4-D, and dicamba, and 82% and 28% of the accessions exhibited ≥50% survivorship when treated with fomesafen and mesotrione, respectively. At the 1× POST rate, ≥50% survivorship was observed in 100%, 88%, 83%, 41%, and 24% of accessions for atrazine, 2,4-D, dicamba, fomesafen, and mesotrione, respectively. At the 3× dose, the proportion of accessions with ≥50% survivorship decreased to 70% for atrazine, 52% for 2,4-D, 27% for fomesafen, 11% for dicamba and 4% for mesotrione. All accessions were fully controlled by glufosinate at all doses, with no survivorship observed. The PRE application of fomesafen, S-metolachlor, atrazine, and mesotrione at the 0.5× dose didn't provide effective control (<90% plant density reduction) on 94%, 79%, 75%, and 56% of accessions, respectively. At the 1× dose, fomesafen, atrazine, and S-metolachlor didn't provide effective control (< 90% plant density reduction) on 82%, 50%, and 28% of accessions. Fifty-two and 50% of the accessions were not effectively controlled by fomesafen and atrazine at the 3× dose. Mesotrione at both 1× and 3× doses, and metribuzin at any dose, were fully effective, reducing 100% plant density of all accessions. This study highlights the alarming widespread resistance to POST herbicides in waterhemp populations across Wisconsin, with several accessions surviving to high doses of atrazine, 2,4-D, dicamba, and fomesafen. Glufosinate, provided consistent and effective POST control, suggesting its continued utility in managing troublesome herbicide-resistant waterhemp accessions. The results underscore the importance of PRE herbicides for waterhemp management, with mesotrione and metribuzin providing effective control across all accessions at the recommended doses. In contrast, atrazine and fomesafen offered limited control as PRE treatments. These findings highlight the need for more diverse and integrated weed control strategies to outpace waterhemp's rapidly evolving resistance, ensuring long-term sustainability in crop production systems.

Response of Two Corn Hybrids to Tolpyralate Combined with Reactive Oxygen Species Generating Herbicides (61)

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Herbicides that inhibit 4-hydroxyphenylpyruvate dioxygenase (HPPD) can be mixed with reactive oxygen species (ROS) generating herbicides to enhance the spectrum, level, speed, and consistency of weed control efficacy; however, the herbicide mixtures can increase corn injury. A total of 5 field trials were conducted from 2021 to 2023 in Ridgetown, Ontario, Canada to determine the sensitivity of two corn hybrids (DKC39-97 and B79N56PWE) to tolpyralate plus ROS-generating herbicides (atrazine, bromoxynil, bentazon or glufosinate) applied postemergence (POST) at the recommended rate (1X) and sequentially to represent a spray overlap (2X) in the field. Tolpyralate plus atrazine, bromoxynil, bentazon, or glufosinate (2X rates) caused greater corn injury in DKC39-97 compared to B79N56PWE at 1, 2, and 4 WAT. Tolpyralate plus atrazine, bromoxynil, bentazon, or glufosinate (2X rates) caused 38, 36, 29, and 18% injury in DKC39-97; but only 5, 20, 9, and 2% injury in B79N56PWE, respectively at 1 week after treatment (WAT). Corn injury in both hybrids decreased over time with ≤2% injury at 8 WAT. Tolpyralate plus atrazine, bromoxynil, or bentazon (2X rates) caused a 17, 16, and 13% height reduction in DKC39-97, respectively at 2 WAT; however, tolpyralate plus glufosinate did not reduce DKC39-97 corn height. Tolpyralate plus bromoxynil or bentazon (2X rates) caused a 12 and 10% height reduction in B79N56PWE, respectively at 2 WAT; however, tolpyralate plus atrazine or glufosinate did not reduce B79N56PWE corn height. Tolpyralate plus atrazine or glufosinate (2X rates) caused a greater corn height reduction in DKC39-97 compared to B79N56PWE at 2 WAT. Grain yield was on average 2% lower in DKC39-97 compared to B79N56PWE. Tolpyralate plus bromoxynil or bentazon (2X rates) caused 7 and 6% corn grain yield reduction compared to tolpyralate plus glufosinate (2X rate). Results indicate that tolpyralate plus ROS-generating herbicides can cause corn injury; the level of corn injury is influenced by corn hybrid and ROS-generating herbicides. Corn producers need to consider the differential sensitivity of corn hybrids and ROS-generating herbicides when using an HPPD-inhibiting herbicide for weed management.

Influence of Deer Repellents and Herbicide Combinations on Weed Control and Deer Browsing in Soybean (62)

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The impact of white-tailed deer browsing on crop yields, specifically soybean yield, has been a problem within agriculture for several decades. In an effort to reduce the substantial losses incurred by deer browsing, several wildlife repellents have been commercialized and marketed for use on soybean. Despite their availability, limited research has been conducted on the ability of these repellents to deter feeding or the effects of these products on weed control when applied in combination with common herbicide treatments. In 2023 and 2024, a field experiment was conducted in four soybean fields to evaluate five commercial deer repellent products (Bobbex, Hinder, Liquid Fence, Penergetic bWV and PlantSkydd+) for their ability to reduce deer browsing on soybean plants. Each product was applied either once, twice, or three times in conjunction with the preplant burndown, early postemergence, and late postemergence herbicide applications, respectively. Regular assessments of deer browsing were conducted at weekly intervals following applications. Across all locations in 2023 and 2024, all applications of repellent products, even three sequential applications of these products, failed to provide any consistent suppression in deer browsing throughout the growing season. An additional field experiment was conducted during both seasons to evaluate the potential impacts of combinations of common herbicides and deer repellents on weed control and soybean injury. Results from these trials indicate that there were no differences in foxtail species (*Setaria* spp.), waterhemp (*Amaranthus tuberculatus*), morningglory species (*Ipomoea* spp.), and common cocklebur (*Xanthium strumarium*) control with any repellent and herbicide combination compared to treatments of post-emergent herbicides alone. Overall, results from these experiments indicate that combinations of these deer repellent products with herbicides in tank mixtures does not increase or decrease weed control when compared to stand-alone herbicide treatments. There is also no evidence to suggest that these repellent products demonstrate an ability to deter deer browsing in soybean.

Comparison of Soybean Variety and Planting Date on Metribuzin Tolerance (63)

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Metribuzin is a preemergence herbicide for weed control in soybean that was registered in the U.S. in 1973. Once widely used, metribuzin use declined with the introduction of ALS-inhibiting herbicides and then glyphosate-resistant soybean. Crop injury concerns due to differential varietal sensitivity and applications to high pH soils were challenges. More recently, metribuzin use has increased since it is a key component for managing herbicide-resistant waterhemp (*Amaranthus tuberculatus*) and horseweed (*Erigeron canadensis*). However, due to injury concerns metribuzin use rates have been reduced. As higher rates of metribuzin are needed for greater control of herbicide-resistant weeds and new soybean genetics are available, it is important to examine crop safety and weed control from increasing rates of metribuzin. In 2024, a field experiment was conducted at Michigan State University on a clay loam soil with a pH of 7.5 and 2.4% organic matter. This experiment was set up as a split-split-plot randomized complete block design with planting date (early = April 14; normal = May 14) as the main plot, two soybean varieties identified various levels of metribuzin tolerance (VAR1 = below average tolerance; VAR2 = above average tolerance) as the sub-plot and increasing metribuzin rates as the sub-sub-plot. Immediately after each planting date, flumioxazin (50 g ha^{-1}) + pyroxasulfone (91 g ha^{-1}) was applied in combination with all metribuzin rates. There was a planting date by soybean variety interaction for soybean injury at 7, 14, and 28 d after soybean emergence (DAE). Overall soybean injury was greatest from the normal planted soybean (~20%) compared with the early planted soybean. This was due to the speed of soybean emergence due to temperature. Precipitation was 3.22 and 0.43 cm within 7 d of planting for the early and normal soybean planting, respectively. Differences in injury between the varieties varied between the different evaluation timings. There was a main effect of metribuzin use rate for each evaluation timing. At 7 and 14 DAE, there was no difference in soybean injury (up to 18%) between the metribuzin rates. However, by 28 DAE only the 630 and 840 g ha^{-1} rates of metribuzin had greater injury (13%) than flumioxazin + pyroxasulfone alone. Soybean recovered from injury at the time of POST treatment, 65 and 36 d after planting for the early and late planting, respectively. All treatments provided excellent common lambsquarters (*Chenopodium album*) control at the time of POST. However, there was a main effect of metribuzin rate for giant foxtail (*Setaria faberi*) and common ragweed (*Ambrosia artemisiifolia*) control. Higher rates of metribuzin improved control of both of these weeds, even though control with flumioxazin + pyroxasulfone alone was 90% for both weeds. The addition of metribuzin at any rate did not reduce soybean yield. Overall, including metribuzin at rates up to 840 g ha^{-1} did not influence soybean yield and can be beneficial for weed control. Additional locations and years are needed to further confirm these findings.

Residual Activity of HPPD-inhibitor Herbicides in Corn (64)

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As more farmers struggle to obtain late season annual grass control in corn (*Zea mays*), various herbicide options are being considered to help solve this problem. Since more HPPD-inhibitor (Group 27) herbicides are being used POST, many wonder how much residual activity (if any) these might be providing on both annual weedy grasses and broadleaves. A preliminary field study was conducted in Centre County, Pennsylvania in 2024 to track efficacy and longevity of residual control of HPPD-inhibitor corn herbicides during the growing season. Studies were arranged in a randomized complete block design with three replications. Herbicides were applied with a small-plot, CO2-backpack sprayer system that delivered 140 L ha-1 thru TeeJet TTI110015 nozzles. Treatments were applied on May 15 to bare soil soon after corn planting. Treatments included: mesotrione (105 g ai ha^{-1}), isoxaflutole (87 g), bicyclopyrone (44 g), tembotrione (92 g), topramezone (25 g), tolpyralate (29 g) and s-metolachlor (2141 g). Adequate activating rainfall occurred within 10 days of application. Visual control ratings of giant foxtail (*Setaria faberi*) and common ragweed (*Ambrosia artemisiifolia*) were collected 4, 7, and 9 WAA. Preliminary data for giant foxtail across the treatments showed that mesotrione provided 62, 23, and 20% control after 4,7, and 9 WAA, respectively; isoxaflutole provided 86, 88, and 80% control; bicyclopyrone provided 72, 48, and 35%; tembotrione provided 67, 43, and 27%; topramezone provided 82, 65, and 52%; tolpyralate provided 67, 50, and 37%; and s-metolachlor provided 98, 97, and 92% control. Whereas initial data for common ragweed showed that mesotrione provided 83, 50, and 40% control after 4,7, and 9 WAP, respectively; isoxaflutole provided 96, 96, and 95% control; bicyclopyrone provided 93, 91, and 86%; tembotrione provided 77, 60, and 43%; topramezone provided 79, 48, and 43%; tolpyralate provided 60, 30, and 35%; and s-metolachlor provided 60, 48, and 33% control. In summary, preliminary results indicate that the HPPD-inhibitor herbicides varied among treatments. However, most of them can provide some initial residual control of both giant foxtail and common ragweed (and likely other annual species), only isoxaflutole provided >80% control of both species and bicyclopyrone provided longer term control of ragweed. Although, none of the Group 27 herbicides provided better control of foxtail compared to s-metolachlor after 9 weeks. Even though some of these herbicides were not sprayed during their typical application timeframe (i.e., POST), these results can provide some insight into how much residual weed control and for how long it could be expected. Thus, the HPPD-inhibitor herbicides do not appear to be viable alternatives for late season residual control of grasses even if applied POST and according to their respective labels. However, further studies are needed to confirm these results.

Tank Mix Evaluation of Atrazine Alternative PSII- and HPPD-Inhibitors for Control of *Amaranthus tuberculatus* and *Ambrosia trifida* in Wisconsin Corn Production Systems (65)

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In Wisconsin, the presence of atrazine prohibition areas leads to overreliance on HPPD-inhibitors (i.e., mesotrione) for control of challenging weeds such as waterhemp (*Amaranthus tuberculatus*) and giant ragweed (*Ambrosia trifida*) in corn (*Zea mays*) production systems. There is a known synergism between PSII- and HPPD-inhibitors that can be utilized to enhance control of troublesome broadleaf weed species. The goal of this study is to evaluate control of waterhemp and giant ragweed POST by tank mixing atrazine alternative PSII-inhibitors 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 in atrazine prohibition areas. A field experiment was conducted following a randomized complete block design with four replications in 2024 at two locations with confirmed herbicide-resistant waterhemp (Brooklyn, WI) and giant ragweed (Janesville, WI); the experiment will be replicated in 2025. At each site, 3 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 2 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; corn was V6 growth stage at Brooklyn and V4 at Janesville. Visual weed control estimates (%) were evaluated 28 days after treatment (DAT), crop injury (%) 14 DAT, and grain yield (kg ha^{-1}) at the end of the season. In general, tank mixing PSII- and HPPD-inhibitors enhanced weed control compared to herbicides alone at both sites. Mesotrione alone controlled waterhemp by 64% which increased to 95% and 91% when metribuzin and bromoxynil were mixed, respectively. Other treatments ranged from 39% to 68% for waterhemp control. Both topramezone and mesotrione alone controlled giant ragweed by 74% and 30%, respectively; addition of bentazon or bromoxynil to each HPPD-inhibitor increased weed control ranging from 87% to 93%. Other tank mix combinations ranged from 59% to 79% for control of giant ragweed. Corn injury was dependent on the choice of PSII-inhibitors. At both sites regardless of tank mixing HPPD-inhibitors, corn injury ranged from 19% to 39% for metribuzin, 1% to 19% for bromoxynil, and 1% to 4% for bentazon. Of the herbicide treatments that were highlighted above with the best weed control at each site, yield was comparable to the weed free check. At Brooklyn, bromoxynil + mesotrione (12,393 kg ha^{-1}) and metribuzin + mesotrione (12,299 kg ha^{-1}) had similar yield averages compared to the weed free check (12,306 kg ha^{-1}) while providing effective waterhemp control (>90%). At Janesville, 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 effective giant ragweed control (>87%). The results of this study provide growers in atrazine prohibition areas with a potentially effective POST herbicide treatment and provide further knowledge about PSII- and HPPD-inhibitors synergism for control of troublesome broadleaf weeds in Wisconsin corn production.

Impact of Row Spacing and Layered Residual Herbicide on Soybean Growth and Yield (66)

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Canopy coverage plays an important role in weed suppression by blocking the incoming lights required for weed emergence and growth and is influenced by various agronomic management practices. The objective of this research was to evaluate the effect of row spacing and ‘layered-residual herbicide’ application in combination with foliar-active postemergence (POST) herbicides on soybean canopy development and yield. Field experiments were conducted in 2023 and 2024 at the Rosemount Research and Outreach Center near Rosemount, MN using a factorial randomized complete block design. The first factor included soybean row spacing as wide-row (76 cm) and narrow-row (38 cm). The second and third factors involved the application of foliar-active POST herbicides (glyphosate, glufosinate, and lactofen) and four layering residual POST treatments (acetochlor, pyroxasulfone, *S*-metolachlor, and no herbicide), respectively. Results showed that at 42 days after treatment (DAT), narrow-row spacing achieved significantly higher canopy cover (93% in 2023 and 97% in 2024) compared to wide-row spacing (86% in 2023 and 93% in 2024). Among the foliar-active herbicides, glyphosate and glufosinate recorded higher canopy cover (90% each) in 2023. However, in 2024, the effect of foliar-active herbicides on canopy cover was similar at 42 DAT. Layered residual herbicides reduced soybean canopy cover; with acetochlor showing the lowest cover (87% in 2023 and 93% in 2024) compared to no residual herbicide (91% in 2023 and 95% in 2024). Soybean yield was not influenced by the row spacing in 2023, but in 2024, wide-row spacing yielded higher (5,512 kg ha^{-1}) than narrow-row spacing (5,339 kg ha^{-1}). Among the foliar-active herbicides, glyphosate recorded maximum yield (3,444 kg ha^{-1} in 2023 and 5,575 kg ha^{-1} in 2024). The plots that received no layering residual herbicide treatments recorded the highest soybean yield of 3,397 kg ha^{-1} in 2023 and 5,510 kg ha^{-1} in 2024. Whereas acetochlor applied as a layering residual treatment reduced soybean yield by 5% in 2023 and 4% in 2024 compared to no layering residual treatment. Therefore, the application of lactofen as POST and the encapsulated formulation of acetochlor applied as layering residual treatment can delay the canopy growth and reduce soybean yield.

Weed Management and Soybean Yield with 2,4-D and Glufosinate Applied Alone, Sequentially, and Mixed (67)

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Field experiments were conducted in soybean to determine the effect of 2,4-D and glufosinate applied alone, mixed, and sequentially on pervasive weed species (common lambsquarters, redroot pigweed, yellow foxtail, and waterhemp) and yield. The experiment was conducted at Beresford (common lambsquarters and waterhemp) and South Shore (redroot pigweed and yellow foxtail), South Dakota during the 2023 and 2024 growing seasons. Initial treatments were applied when the weeds were 15 cm in height. Sequential herbicide treatments were applied 12 days after the initial treatment. 2,4-D and glufosinate alone provided the least control of all tested weed species. Sequential treatments provided greater control for all tested species. However, two applications of glufosinate were needed to control yellow foxtail greater than 80%. 2,4-D + glufosinate additively controlled all tested weed species. Soybean yield was greater with most sequential applications compared to single applications at Beresford. Soybean yield was greater with two applications of glufosinate compared to the other treatments at South Shore. The results of the experiment provide evidence that 2,4-D and glufosinate are more effective on pervasive weed species when applied mixed or sequentially and what species are present may dictate how the herbicides are applied together. Sequential herbicide applications may be necessary to achieve higher yields based on the species present.

Target and Non-target Site Resistance in Diverse Johnsongrass (*Sorghum halepense*) Populations (68)

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Johnsongrass (*Sorghum halepense*) is one of the world's most troublesome perennial weeds, inflicting environmental and economic damage. Johnsongrass has long been problematic in the southern regions of the United States, with climate change bringing these problems northward. Further exacerbating control are herbicide resistant populations of johnsongrass. Over 30 cases of herbicide resistance have been reported in johnsongrass to four sites of action. Acetolactate synthase (ALS) inhibitors are one site of action where resistant reports of johnsongrass are extensively noted. Given these factors, the objectives of this study were to determine baseline herbicide sensitivity in populations collected from across the United States and to determine the resistance mechanism. Populations have been collected from 22 states including: Alabama, Arizona, California, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Kentucky, Maryland, Michigan, Nebraska, New York, Ohio, Pennsylvania, North and South Carolina, Tennessee, Texas, Virginia, and West Virginia. To determine baseline sensitivity populations were submitted to dose response assays. Dose response assays consisted of seven nicosulfuron, glyphosate, clethodim, imazethapyr, and thiencarbazone-methyl rates with four replications. The dose treatments ranged from 0.125 to 64 times the field use rate of 0.09 kg ha^{-1} for nicosulfuron and 0.125 to 8 times the field use rates of 1.61, 0.65, 0.26, and 1.4 kg ha^{-1} for glyphosate, clethodim, imazethapyr, and thiencarbazone-methyl, respectively. Resistance reversal experiments were conducted with populations that did not contain known SNPs conferring resistance to ALS inhibitors. Malathione (2000 g ha^{-1}) was applied three hours prior to nicosulfuron application. Nicosulfuron treatments after malathione application ranged from 0.5 to 4 times the field use rate of 0.09 kg ha^{-1}. Applications were made using a greenhouse track sprayer. Visual injury ratings were conducted weekly. Three weeks after application, aboveground plant biomass was collected, dried, and weighed. Dose response data was analyzed using the drc package in R to estimate the dose that causes 50% injury (ED_{50}). Target-site ALS resistance in these populations were analyzed by isolating DNA following a CTAB protocol and Sorghum halepense primers were used to amplify the ALS gene. None of the populations are resistant to glyphosate or clethodim, with ED_{50} values ranging from 0.04-0.73 and 0.07-0.15 kg ha^{-1}, respectively. Twenty-seven percent of the populations screened are resistant to nicosulfuron and 63% of the nicosulfuron resistant populations are also resistant to thiencarbazone-methyl and imazethapyr, with ED_{50} values ranging from 0.09-5.06, 2.01-11.2, and 0.28-2.08 kg ha^{-1}, respectively. Resistant populations were collected in Michigan (5), Indiana (1), Maryland (1), Ohio (1), and Texas (1). Seven populations contain a SNP at the Trp_{574}, which confers broad spectrum resistance to ALS inhibitors. Three populations from Ohio (1) and Texas (2) did not contain any SNPs. The added malathione treatment decreased the ED_{50} from 0.05 to 0.02, 0.09 to 0.02, respectively. Future research will investigate the impacts of projected climate change on herbicide sensitivity. This future work will contribute to the current knowledge gap surrounding herbicide efficacy in a changing environment.

Evaluating Glufosinate Resistance in a Waterhemp (*Amaranthus tuberculatus*) Population from Southern Illinois (69)

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Herbicide resistance is a significant threat in the 21st century, limiting crop yield and increasing production costs. Waterhemp (*Amaranthus tuberculatus* (Moq.) J.D. Sauer) is the most common and second most troublesome weed in soybean fields. To date, it has evolved resistance to seven herbicide site of action (SOA) groups (2, 4, 5, 9, 14, 15, and 27) in Illinois, leaving few effective postemergence control options. This study aimed to characterize a suspected glufosinate-resistant population, identified in a previous screening having reduced susceptibility to glufosinate (SOA 10). Seeds from the suspected-resistant population (Franklin) were collected in October 2022. Two susceptible populations (BRC and Carlyle) were included in the screening for comparison. The seeds of each population were initially sown in flats (25.5 cm x 25.5 cm), and once seedlings reached the first true leaf stage, individual plants were transplanted into plastic cells of 0.16 L volume. The greenhouse trial was designed as a randomized complete block design with two runs each having 30 replications. Glufosinate was applied at six rates: 163 (0.25x), 327 (0.5x), 654 (1x), 1310 (2x), 2620 (4x), and 5230 (8x) g ai ha^{-1}, plus AMS at 2.5% v.v. The 1x rate represents the full field rate applied over the top in postemergence. A nontreated control was included in each experimental run. Applications were made when plants reached 7.5 to 10 cm in height using a spray chamber equipped with an 8002EVS nozzle, calibrated to deliver 140 L ha^{-1} at 3.5 km h^{-1}

with 30 PSI. Plants were grown in a greenhouse with a 16-hour photoperiod, watered as needed, and fertilized every three days with a 20:20:20 NPK liquid fertilizer. Three weeks after the application, aboveground plant biomass was collected, dried, and weighed. The data were analyzed using the *drc* package in RStudio to estimate the effective dose causing 50% injury (ED_{50}) based on dry biomass. Runs were analyzed separately due to variability in susceptibility, which may be explained by temperature and humidity differences, both of which play a major role in glufosinate efficacy. The suspected-resistant population Franklin showed a high level of resistance in both runs (ED_{50}: 361.36 ± 35.91; ED_{50}: 519.3 ± 68.56) when compared to the two susceptible BRC (ED_{50}: 240.91 ± 32.70; ED_{50}: 90.77 ± 37.53), and Carlyle (ED_{50}: 306.41 ± 40.44; ED_{50}: 225.74 ± 35.65). Franklin had a survivorship of 56% the 1x rate, and 26% at the 2x rate. More research is ongoing to characterize this population for resistance to other SOAs and to examine the mechanism and heritability of the resistance trait. These initial findings highlight the critical need for a proactive approach to delay the evolution of herbicide resistance and preserve the technologies available.

Effect of Soil-applied Nitrogen on Weed Germination and Control with Herbicides in Soybean (70)

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Nitrogen fertilizer is applied to crops to increase vigor and yield. Nitrogen can also influence seed germination and susceptibility to herbicides. Field experiments were conducted in soybean to determine if soil-applied nitrogen fertilizer could increase weed germination, weed susceptibility to herbicides, and yield. Experiments were conducted in South Shore and Volga, South Dakota during the 2023 and 2024 growing season. Redroot pigweed and waterhemp inhabited the South Shore and Volga locations, respectively. *S*-metolachlor and soil-applied nitrogen (0 to 56 kg ha^{-1}) were applied in factorially arrangement at planting. Waterhemp germination increased with increasing soil-applied nitrogen rates while redroot pigweed germination was not affected. Weed germination was less with the application *S*-metolachlor but was not affected by increasing nitrogen rate. Glufosinate (655 g ai ha^{-1}) was applied when weeds were 15 cm in height at each location. Redroot pigweed control with glufosinate was not influenced by *S*-metolachlor or nitrogen rate. Waterhemp control with glufosinate was similar with all tested soil-applied nitrogen rates but control was higher with *S*-metolachlor. Yield was not affected by soil-applied nitrogen rate but yield was increased with the application of *S*-metolachlor. The results of this experiment provide evidence that soil-applied nitrogen can increase weed germination but the inclusion of *S*-metolachlor did not increase control. Results also suggest that the tested soil-applied nitrogen rates do not influence glufosinate susceptibility. While soil-applied nitrogen did not increase soybean yield, the implications of weed control could warrant application.

The Effects of Soybean Planting Date and Metribuzin Rates on Waterhemp (Amaranthus tuberculatus) Control, Soybean Injury, and Yield (71)

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Waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] is rapidly becoming one of the biggest weed problems in Ohio, due to its prolonged length of emergence, prolific seed production, and rapid herbicide-resistance development. Metribuzin, when used as a pre-emergence (PRE) herbicide, provides good control of waterhemp. Despite metribuzin efficacy, farmers may hesitate to include it in herbicide programs due to crop injury concerns. A field study was conducted in 2024 in South Charleston, OH to evaluate different metribuzin rates in comprehensive herbicide programs to maximize PRE waterhemp control and minimize crop injury in early and late planted soybeans [*Glycine max* (L.) Merr.]. The two factors evaluated in this study include: 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 or normal). This study was a fully factorial randomized complete block design with 16 treatments and 4 replications. Measurements to evaluate treatment effect included crop injury, soybean stand count, waterhemp density, and soybean yield. There was no difference in waterhemp density between the different herbicides, which were all lower than the untreated check at all timings. At the 14 days after soybean emergence (DAE) and at the POST evaluations, the early planting date had greater waterhemp density, averaged across herbicide treatments. At the 14 and 28 DAE evaluations, the early planted soybeans had less injury than the late planted. This was likely due to the delayed emergence of the early planted soybeans, which occurred 21 days after planting and application, relative to normal planting which took 11 days to emerge. The treatments receiving sulfentrazone and fomesafen had less injury, while there was no difference in the treatments between flumioxazin + pyroxasulfone + metribuzin at any rate. The normal soybean planting date had more soybean plants ha-^{1} as compared to the early planted soybeans. However, the early planted soybeans yielded 269 kg ha-^{1} higher than the later planted. In this study, metribuzin rate did not influence soybean injury, but planting date did, likely due to application timings. This data suggests that metribuzin is an effective option for waterhemp management in Ohio.

Confirmation of Multiple Herbicide Resistance in Waterhemp (*Amaranthus tuberculatus*) Population from Northeast Kansas (72)

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Waterhemp in the United States has evolved resistance to seven different herbicide sites of action and is suspected to be resistant to glutamine synthetase (GS) inhibitors. This study aimed to investigate waterhemp resistance to multiple herbicides and to evaluate the level of resistance to glufosinate-ammonium. Greenhouse experiments were conducted during the summer of 2024, with six waterhemp populations from northeast Kansas fields (labeled K1 to K6) and one known susceptible population (S1) that were screened with recommended field doses of glufosinate-ammonium, glyphosate, 2,4-D (choline salt), fomesafen, mesotrione, and lactofen. Subsequently, a dose-response study with glufosinate-ammonium was run on four populations (K2 to K5) and two known susceptible populations (S1 and S2), with doses of 0 (NT, non-treated), 147.5, 295, 590 (recommended dose 1X), 1180, and 2360 g ha^{-1} , including non-ionic surfactant at 0.25% v/v. Three weeks after treatment (WAT), the plants were visually assessed for injury on a scale from 0 to 100%, where 0% indicates no injury and 100% indicates complete plant death, compared to the non-treated controls. Above-ground biomass was harvested 3 WAT. For the screening study the resistance level was classified as three categories based on percent survival; <2% = susceptible, 2% to 19% = low resistance, and 20% to 100% = resistant. The results of the screening studies demonstrated that 2,4-D was the most effective treatment for waterhemp control in all the populations except K3 with low resistance. For glufosinate, the K6 population had low resistance (3%), while the remainder were classified as resistant. For glyphosate, lactofen, mesotrione, and fomesafen, all the populations were classified as resistant. The two experimental runs were combined for the dose-response study. Based on shoot biomass reduction, K3 and K4 populations were 1.8 and 1.1 times more resistant to glufosinate-ammonium, respectively, compared to the S1 population. Additionally, K3 was 1.5 times more resistant than the S2 population. The ED_{50} estimates from the dose-response curves indicated that the K3 population had the highest ED_{50} value of 102 g ha^{-1}. In terms of waterhemp control, the K3 population was the least affected at the recommended field dose (590 g ha^{-1}). Based on our findings, waterhemp in northeast Kansas fields demonstrate a complex resistance profile, with varying levels of susceptibility and resistance across multiple different herbicides. The implications are important for designing resistance management strategies, highlighting the need for diverse and integrated weed control approaches. Given that glufosinate resistance is present but not uniformly distributed across populations, targeted management practices, potentially involving rotation or a mixture of herbicides with unique sites of action, are recommended. This study underscores the urgency of implementing resistance management practices to preserve the efficacy of glufosinate-ammonium and other herbicides for effective waterhemp control.

Surtain Herbicide: A New Residual Herbicide for Weed Control in Corn from BASF (73)

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Surtain™ herbicide is a novel formulation that will be commercially introduced by BASF Corporation in 2025 offering a broad-spectrum residual premix with PRE and POST flexibility in corn. Surtain™ herbicide is a premix of saflufenacil (capsulated) and pyroxasulfone and is labelled for use in field corn grown for grain, seed, or silage. 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. Furthermore, Surtain™ herbicide will offer flexibility to corn growers expanding the application window. 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. Besides these benefits, Surtain™ herbicide will be a relatively low use rate herbicide (9.2 to 17 fl. oz/A depending on soil texture) with enhanced liquid fertilize compatibility. Surtain™ herbicide obtained Federal and State registrations earlier this year and will is expected to be launched by BASF Corporation to the corn market for use in the 2025 season.

Evaluating Photosystem II Inhibitor Herbicides on Atrazine-Resistant *Amaranthus tuberculatus* (74)

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Resistance to photosystem-II (PSII)-inhibiting herbicides in the driver weed, *Amaranthus tuberculatus* (waterhemp), has been widely linked to a $Ser^{264}Gly$ amino acid substitution in the D1 protein target site of PSII. However, fitness costs associated with this resistance mechanism and continuing use of atrazine are contributing to an increasing number of metabolic non-target-site (NTS) resistance cases. Previous research has implicated the overexpression of a phi-class glutathione S-transferase (AtuGSTF2) as a key factor in the metabolic detoxification of atrazine, but the diverse PSII-inhibiting chemistries may not be recognized similarly. Therefore, the main objective of this research was to assess the effectiveness of non-triazine PSII inhibitors against atrazine-resistant *A. tuberculatus*. Dose-response experiments were conducted with triazine (atrazine) and non-triazine (amicarbazone, metribuzin) PSII inhibitors on populations with varying levels of atrazine resistance: WUS (sensitive), ACR and MCR (NTS resistant), and TSR (target-site resistant). WUS was controlled well below recommended field rates by all herbicides, while consistent control was not achieved at any rate for TSR. ACR and MCR, respectively, displayed approximately 21-fold and 15-fold resistance to atrazine compared to WUS, but could be effectively controlled by both amicarbazone and metribuzin applied alone or in combination. We modeled the *A. tuberculatus* D1 protein *in-silico* and performed molecular docking analysis to compare the binding conformations and affinities of these herbicides at the D1 target site within the plastoquinone-B (Q_B) pocket. Docking analysis showed that all three herbicides positioned consistently within the Q_B pocket, orienting their polar reactive groups to form conserved hydrogen bonds with Ser^{264} and Phe^{265} residues. Amicarbazone had additional contacts and a bond with His^{252}, resulting in the highest binding affinity for this herbicide, followed by metribuzin. Together, these findings indicate that amicarbazone and metribuzin, applied alone or in combination, offer effective alternatives for managing at least some NTS atrazine-resistant *A. tuberculatus* populations.

Palmer Amaranth Management Following Harvest Aid Herbicide Application in Cotton (75)

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Cotton harvest aid herbicides are used to defoliate cotton plants and open cotton bolls to assist in harvesting. Many of the products used will also control or suppress problematic weeds, such as

Palmer amaranth (*Amaranthus palmeri*). Field trials were conducted in commercial cotton production fields near Mount Hope and Bently, Kansas in 2023 and 2024. Cotton crops were established in May, and initial herbicide applications were performed at planting according to the farmers' preferences. Seven defoliant treatments [tributyl phosphorotrithioate (1.7 L/ha), carfentrazone (73.0 and 116.8 mL ha^{-1}), tiafencil (73.0 and 219.1 mL ha^{-1}), and saflufenacil (73.0 and 146.0 mL ha^{-1})] were applied at 50% and 75% open cotton bolls. Ethephon (3.4 L ha^{-1}) was included in all treatments as a boll opener. Two weeks after the application, weed density, percent defoliation, and percent open bolls were assessed. Cotton bolls and Palmer seed heads were collected at this time as well for later alalysis. Percent open bolls was found to be significantly higher in the treatments sprayed at the 75% timing. At Mount Hope, the later timing also resulted in a greater rate of defoliation. Saflufenacil at a high rate and late timing resulted in the highest defoliation rate. No significant difference in Palmer seed counts or biomass between different treatments was found.

Efficacy of Diflufenican for Controlling Multiple Herbicide-Resistant Waterhemp in Soybean (76)

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Waterhemp biotypes have evolved resistance to Weed Science Society of America (WSSA) Herbicide Groups 2, 5, 9, 14, and 27 in Ontario Canada, are present in 15 counties, spanning a distance of 800 km across southern Ontario, and cause an average soybean yield loss of 42%. Five field experiments were established in growers' fields in southwestern Ontario to determine the biologically effective doses of diflufenican (Group 12) applied preemergence (PRE) to control multiple herbicide-resistant waterhemp in soybean. The calculated diflufenican doses to elicit 50, 80, and 95% control of MHR waterhemp were 71, 164, and 304 g ai ha^{-1} at 2 weeks after herbicide application (WAA); 50, 115, and 214 g ai ha^{-1} at 4 WAA; and 69, 158, and 294 g ai ha^{-1} at 8 WAA, respectively. The calculated diflufenican doses that caused a 50, 80, and 95% reduction in MHR waterhemp density were 28, 70, and Non-est. g ai ha^{-1} and the doses that caused a 50, 80, and 95% reduction in MHR waterhemp biomass were 44, 109, and Non-est. g ai ha^{-1}, respectively. The calculated diflufenican doses that resulted in 50, 80, and 95% of the soybean yield of the industry standard herbicide (flumioxazin/pyroxasulfone) were 3, 12, and 57 g ai ha^{-1}, respectively. Diflufenican (180 g ai ha^{-1}) PRE controlled MHR waterhemp 89, 92, and 85%; metribuzin (300 g ai ha^{-1}) PRE controlled MHR waterhemp 94, 84, and 69%; and flumioxazin/pyroxasulfone (105/134 g ai ha^{-1}) PRE controlled MHR waterhemp 100, 99, and 98% at 2, 4, and 8 WAA, respectively. Diflufenican, metribuzin, and flumioxazin/pyroxasulfone applied PRE reduced MHR waterhemp density 96, 84, and 100% and biomass 93, 67, and 99%, respectively at 8 WAA. Diflufenican, metribuzin, and flumioxazin/pyroxasulfone applied PRE caused 9, 0, and 4% visible soybean injury, respectively but the injury was transient and caused no adverse effect on seed moisture content or seed yield of soybean. This study concludes that diflufenican and metribuzin applied PRE provide comparable MHR waterhemp control; however, control was lower than flumioxazin/pyroxasulfone.

Poster Section - Weed Biology and Ecology

Assessing Weed Seedbank Changes in Soybeans under Winter Wheat Double Cropping and Nitrogen Fertilizer Management (77)

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Quantification of the weed seedbank allows assessment of long-term changes in weed flora in response to various management practices, such as double cropping (DC) winter wheat (WW; *Triticum aestivum* L.) in soybeans (*Glycine max* L.). The objective of this study is to examine the impact of double crop WW and its nitrogen (N) management on the weed seedbank in the soybean cropping system, as compared to the impact of a cereal rye (CR; *Secale cereale* L.). Weed seedbank emergence was quantified through the collection of soil samples from trials at the Agronomy Research Center (ARC), Carbondale, and Belleville Research Center (BRC), Belleville, IL in fall 2022 and spring 2023. The study was laid out in a randomized complete block design with 5 treatments and 4 replicates. Treatments were: 1) Corn (C)-no-cover crop (CC)-Soybean (S)-no-CC (control), 2) C-CR-S-CR (maximum nitrate-N reduction control), 3) C-WL (wheat low input)-S-no-CC, 4) C-WM (wheat medium input)-S-no-CC, and 5) C-WH (wheat high input; growers' suggestions)-S-no-CC. The WW and CR were planted at 140 kg ha^{-1} and 87 kg ha^{-1}, respectively. Soybeans were planted at the rate of 179,000 kg ha^{-1}. The low input fertilizer treatments were 30 kg of N ha^{-1} of Diammonium Phosphate (DAP) and 45 kg of N ha^{-1} of Urea Ammonium Nitrate (UAN) applied at tillering and jointing; the medium input were 30 kg of N ha^{-1} of DAP and 78 kg of N ha^{-1} of UAN, applied at the tillering and jointing stages; the high input treatments were 30 kg of N ha^{-1} of DAP during the fall season, in addition to 78 kg of N ha^{-1} of UAN, applied at both tillering and jointing stages. Soil samples were collected from each subplot at 10 cm depth and grown-out in the greenhouse. Greenhouse grow-outs occurred 3 times at 4-week intervals until the seedbank was exhausted, with weeds enumerated by species. Eight weed species qualified as the most common or troublesome weed species in the grow-out and analyzed for treatment differences, along with community diversity measures (Shannon-Weiner diversity index (H'), richness (S), and evenness (J'). The weed diversity (H') was higher in: (i) fall 2022 than in spring 2023, suggesting seasonal variation in weed emergence (ii) ARC than BRC, indicating geographic influences on weed seedbank emergence, potentially due to soil composition and climatic factors, and (iii) in plots double-cropped with WW at high N compared to plots with CR and no cover crop (NO-CC), suggesting a N effect that favors weed diversity. In fall 2022, the plot with WW and low fertilizer input had higher weed diversity than the NO-CC plot, possibly suggesting an environment which minimizes the likelihood of dominance by a single weed species. However, no differences were observed for S or J' or individual species in fall 2022 or spring 2023. Incorporating WW alongside a low-input fertilizer regimen may improve ecological diversity within the weed community. Future studies will investigate the long-term effects of WW and N management on weed diversity, species richness, and evenness across multiple growing seasons.

Exploring the Potential of Black Soldier Fly Compost Tea for Weed Suppression (78)

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Weeds present a significant challenge in agriculture by reducing crop yields and demanding frequent control measures. Black soldier fly (*Hermetia illucens*) compost tea, produced from digested organic waste, has garnered recent interest as a soil amendment due to its unique chemical and microbial properties. While studies have examined its use in soil health, its potential phytotoxicity and effects on weed suppression remain underexplored. In 2024 laboratory studies were conducted to determine the effect of black soldier fly compost tea on the germination of barnyardgrass (*Echinochloa crus-galli* L.) and redroot pigweed (*Amaranthus retroflexus* L.). Dried black soldier fly compost (frass) was mixed with distilled water (0.25 g ml^{-1}), shaken for 30 minutes, then left for 24 hours. The 1:4 compost tea was diluted to create a dose-response series of 0.03, 0.06, 0.09, 0.12, 0.15, 0.18, and 0.2 g ml^{-1}. Twenty weed seeds of each species were placed onto separate petri dishes then treated with 3 ml of each tea concentration. Petri dishes were placed into a growth chamber set to 18°C at night and 30°C during the day, with a 14-hour light photoperiod for two weeks. At 7 and 14 days after treatment germinated seedling were counted and then removed. Both weed species were fit to 3-parameter logistic models The dose required to reduce germination by half (ED50) was 0.066 g ml^{-1} for barnyard grass and 0.03 g ml^{-1} for redroot pigweed. These findings suggest that black soldier fly compost tea could serve as an eco-friendly, low-dose weed management tool. However, additional studies are needed in situ to determine if the results from this trial are applicable to field conditions.

Relative Volatility of Amicarbazone, Atrazine, and Metribuzin under Laboratory Conditions (79)

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Herbicide dissipation is a complex process where each individual scenario is governed by a unique set of conditions that will determine the most important loss mechanism. Volatilization can be a critical pathway for herbicide loss from agricultural fields with possible results being reduced herbicide efficacy and/or 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. The two types of sampling media included a "filter paper" followed by a Polyurethane Foam plug (PUF). 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 two herbicides showed several orders of magnitude greater herbicide concentrations. Future research is needed to confirm these results, and to correlate them to soil and environmental conditions.

The Distribution and Frequency of Waterhemp (*Amaranthus tuberculatus*) in Ohio Soybean Fields Prior to Harvest from 2021 to 2024 (80)

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Scouting for end of season weed escapes is an important step in the process of identifying and monitoring the spread of herbicide resistant weed populations. Waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer) is a noxious weed species with known resistance to multiple herbicide modes of action that threatens soybean (*Glycine max* L.) production in Ohio. Herbicide resistant waterhemp was first documented in western Ohio in 2008 and has steadily been climbing in the list of Ohio's top 5 troublesome weeds over the past eight years. The objective of this study was to determine the distribution and frequency of late season waterhemp infestations in Ohio along with how the levels of infestation have changed over time. Each fall, the agronomic weed science program at Ohio State conducts a weeds survey prior to soybean harvest and evaluates fields for the presence and infestation level of 10 weeds species to forecast weed management problems in Ohio. From 2021 to 2024, soybean fields in Ohio were evaluated with this survey to determine late season frequency of waterhemp. In that 4-year interval, 47 counties in Ohio have been surveyed. Counties are driven by region according to the drought map and harvest progress, and approximately 80 to 100 soybean fields are surveyed per county. Soybean fields were rated on a scale of 0 to 3, with 0 indicating no waterhemp were present, 1 representing an occasional individual plant, 2 representing large patches of 8 or more plants, and 3 representing widespread, numerous patches or individual plants of the species across the field. Data analysis and visual creation were done in R using the ggplot2 and tidyverse packages. Results of this survey show that the number of counties reporting waterhemp presence has increased every year from 2021 to 2024 from 36 counties to 44 counties. The number of individual fields infested with waterhemp has increased from 232 fields to 445 fields from 2021 to 2024. Waterhemp had the highest number of total field infestations of the top five weed species in Ohio in 2024 with 445 fields. The number of fields with a level 1 infestation has increased each year, while the number of fields with level 2 or level 3 infestations has remained constant. In 2021, 11 counties had no waterhemp encounters, 3 counties had no waterhemp encounters in 2022 and 2023, and 4 counties had no waterhemp encounters in 2024. These conclusions show that waterhemp has been an increasing problem, both in number of counties effected and the percent of fields with waterhemp present late season, and for Ohio farmers as the number of fields with occasional individual present also increases.

Pre-emergence Herbicide Effects on Iron Deficiency Chlorosis Severity in Soybean (81)

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Iron Deficiency Chlorosis (IDC) is a major yield reducing factor in high pH soils in the upper northern plains, primarily affecting soybean (*Glycine max)*. Predicting where IDC will appear within fields is very difficult due to several soil factors all working together to create an IDC-susceptible environment. Research has been conducted on postemergence herbicides in soybean to determine if it will add stress to the crop and further worsen the severity of IDC and reduce yield. However, minimal research has been conducted on preemergence herbicides and IDC. The objectives for this research were to 1) evaluate if different preemergence herbicides affect IDC development and severity, and 2) determine if there is any effect on soybean canopy development and yield. This experiment was conducted in three locations: Prosper and Hillsboro, North Dakota; and Glyndon, Minnesota. The trials were conducted in a randomized complete block design with 4 replications. There were ten treatments: 8 herbicide treatments, a non-treated check, and a weed-free check. Herbicide treatments consisted of two commercial soybean herbicide premixtures, and their individual active ingredients: a premixture of pyroxasulfone at 91 g ai ha^{-1} & imazethapyr at 52.5 g ai ha^{-1} & saflufenacil at 18.7 g ai ha^{-1}, and a premixture of *S*-metolachlor at 1940 g ai ha^{-1} & cloransulam-methyl at 36.5 g ai ha^{-1} & metribuzin at 360 g ai ha^{-1}. Herbicide-treated plots were maintained weed-free throughout the season. Data collection consisted of visible injury and IDC ratings, SPAD (soil plant analysis development) measurements, which measures levels of chlorophyll in the plant, canopy development through use of Canopeo, and yield (kg ha^{-1}). The location in Glyndon, MN was planted on May 8, and received over 15 cm of precipitation before soybean emergence. Hillsboro and Prosper were planted on June 7 and June 9, respectively, and each received at least 2.54 cm of precipitation within 1 week of planting. In Glyndon, no herbicide injury was observed, though plant development was stunted due to water-logged soil conditions. IDC symptoms developed throughout the growing season, but there were no differences across treatments in SPAD measurements or yield data. IDC symptoms never developed in ND locations. In Hillsboro, the premixture of *S*-metolachlor & cloransulam-methyl & metribuzin caused visible soybean injury throughout the growing season, yet this did not lead to a reduction in yield. No other herbicide treatment caused soybean injury, and there were no differences in yield across all treatments. In Prosper, no soybean injury was observed, and there were no differences in SPAD measurements or canopy development. The weedy check resulted in lower yield compared to all other treatments, however, there were no differences between the herbicide treatments themselves. Further field and greenhouse research will be conducted to determine if these active ingredients applied preemergence can increase the severity of IDC in soybean.

The Benefits of Overlapping Residual Herbicides in Weed Management Programs for Multiple Herbicide-Resistant Amaranthus Populations in Corn (82)

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Multiple herbicide-resistant waterhemp (*Amaranthus tuberculatus* [Moq.] Sauer.) and Palmer amaranth (*Amaranthus palmeri* S. Watson) have become difficult to control with traditional herbicide programs in corn. Field trials across multiple sites were implemented during 2024 to evaluate herbicide programs consisting of robust residual herbicide rates and overlapping residuals for the control of multiple herbicide-resistant Amaranthus spp. populations on LibertyLink® and Roundup Ready© 2 Corn Data concluded that robust rates of overlapping residuals applied as a PRE fb early POST provided effective control of multiple herbicide-resistant *Amaranthus* spp. on LibertyLink® and Roundup Ready© 2 Corn.

Poster Section - Weed Genetics and Herbicide Physiology

Expression of *HPPD* and *CYP* Genes in Triketone-Resistant Transgenic Wheat (83)

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Weed infestation is one of the major factors contributing to reduced wheat yields. Currently, herbicide-resistant wheat technologies are limited. Therefore, broadening herbicide options for weed management is needed. Hydroxyphenylpyruvate dioxygenase (HPPD)-inhibitors (e.g., mesotrione) provide a broad spectrum of weed control. However, they are not registered for use in wheat due to crop injury. Metabolic resistance to HPPD-inhibitors *via* cytochrome P450 enzyme activity was reported in corn. Additionally, alterations in the *HPPD* gene, the molecular target of these herbicides provided resistance to these herbicides in soybean. Previously, we developed callus derived T_0 transgenic wheat lines overexpressing genes of interest (GOI), i.e., *CYP81Q32*-like or *TaHPPD* genes *via* particle bombardment. Further, the T_1 generation of wheat plants were regenerated and screened for the presence of GOI and phenotypes with mesotrione treatment. The T_1 lines that displayed reduced sensitivity to mesotrione were advanced to T_2 generation. The objective of this study was to identify the T_2 plants with the presence of *CYP81Q32*-like or *TaHPPD* and assess their response to mesotrione. We hypothesize that overexpression of these genes will reduce sensitivity to mesotrione. T_2 plants were grown under controlled environment conditions. PCR analysis found the T_2 plants positive for GOI while quantitative RT-PCR identified mRNA transcript expression for GOI. In response to 6X (1X= 105 g ai ha^{-1}) dose of mesotrione, several T_2 plants exhibited reduced visual injury at 3 and 4 weeks after treatment. These results suggest that overexpression of the genes *CYP81Q32*-like or *TaHPPD* successfully reduced mesotrione sensitivity in T_2 transgenic wheat, with a possibility of developing HPPD-inhibitor resistant wheat in the future.

Ethofumesate Controls *Amaranthus* spp. Preemergence in Sugarbeet (84)

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Ethofumesate use in sugarbeet in Minnesota and North Dakota has increased with the advent of glyphosate resistant weeds, especially glyphosate resistant waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] in the sugarbeet growing region in Minnesota and North Dakota. Hectares treated with ethofumesate soil applied or postemergence increased from 28,045 to 163,048 or 480% between 2020 and 2023 at American Crystal Sugar Cooperative. Similar changes in grower practices have occurred at Southern Minnesota Beet Sugar Cooperative and Minn-Dak Farmers Cooperative. Multiple ethofumesate brands are used by producers including Nortron®, Maxtron 4SC®, Ethotron®, and Ethofumesate 4SC®. Three experiments were conducted at multiple locations in 2024 to evaluate: a) fall vs. spring ethofumesate application; b) waterhemp control with different brands; and c) incorporation (PPI) versus preemergent (PRE) ethofumesate application across rates and resultant length of redroot pigweed (*Amaranthus retroflexus* L.) control. Experiments were conducted near Beaver Creek, MN, Horace, ND and Moorhead, MN in 2024. Herbicides were applied using a bicycle wheel plot sprayer with a shielded boom to reduce particle drift and calibrated to deliver 159 L ha^{-1} through 8002XR nozzles (XR TeeJet® Flat Fan Spray Tips, TeeJet® Technologies, Glendale Heights, IL) spaced 51 cm apart and pressurized with CO2 at 207 kPa. Evaluations were a visible assessment of control by comparing the treated area in the plot to the bordering non-treated area. Waterhemp control following fall or spring ethofumesate application was the same 37 DAT (days after treatment) but control was better following at planting application, 47 DAT. Waterhemp control was the same across brands at Moorhead but Nortron, Maxtron and Ethotron controlled waterhemp better at Beaver Creek than Ethofumesate 4SC. Ethofumesate application PRE provided significantly better redroot pigweed control than PPI application. We attribute this to rainfall; site received 3 cm rainfall the evening of application. Ethofumesate PPI or PRE controlled pigweed better at 3.4-4.2 kg ha^{-1} than ethofumesate at 2.2 kg ha^{-1} 24-44 days after application.

Different Nontarget-site Mechanisms underlie Resistance to Dicamba and 2,4-D in an *Amaranthus tuberculatus* Population (85)

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The use of synthetic auxin herbicides has significantly increased in recent years, leading to strong selective pressure for herbicide-resistant weed populations. In Illinois, a multiple-herbicide-resistant population of waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer), referred to as CHR, evolved resistance to dicamba and 2,4-D. The mechanism for dicamba resistance was previously characterized as an enhanced oxidative stress response, while 2,4-D resistance is thought to be due to enhanced metabolism, likely mediated by cytochrome P450 enzymes. The specific genes contributing to these non-target site resistance (NTSR) mechanisms remain unknown. In this study, we utilized a combination of linkage mapping and transcriptome analysis to investigate whether the same NTSR mechanism confers resistance to both dicamba and 2,4-D and to identify the genomic regions associated with these resistance traits in the CHR population. Phenotypic evaluations of clones derived from 188 individuals of an F_2 mapping population indicated that resistance traits are polygenic. We observed significant differences in the effects of dicamba and 2,4-D among the clones, resulting in only a weak phenotypic correlation between these resistance traits ($r = 0.2$, $p = 0.005$). Linkage mapping analyses revealed eight quantitative trait loci (QTL) associated with resistance to dicamba and 2,4-D, which were distributed across seven waterhemp chromosomes. These QTL regions accounted for 24.2% of the variation in dicamba-resistant phenotypes and 23.1% of the variation in 2,4-D-resistant phenotypes. Only one QTL region was found to co-localize for both resistance traits. Overall, the findings of this study demonstrate that resistance to dicamba and 2,4-D in the CHR population is controlled by genes located at multiple loci. The weak phenotypic and genetic correlations between these resistance traits suggest that more than one NTSR mechanism contributes to the resistance of dicamba and 2,4-D in this waterhemp population.

The Effect of Elevated Temperatures on Expression of Metabolic Herbicide Resistance in Waterhemp (*Amaranthus tuberculatus*) (86)

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Our objective was to characterize the effect of elevated temperatures on the expression of 2,4-D, atrazine, mesotrione, and glyphosate metabolic resistance in a waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] accession (A101). Dose-response experiments were conducted to evaluate the response of A101 to 2,4-D (1x: 1065 g ae ha^{-1} + 1429 g ha^{-1} AMS), atrazine (1x: 1121 g ai ha^{-1} + 0.8 v/v % HSOC), glyphosate (1x: 841 g ae ha^{-1} + 1429 g ha^{-1} AMS), and mesotrione (1x: 105 g ai ha^{-1} + 0.8 v/v % HSOC + 1429 g ha^{-1} AMS). Herbicides were evaluated in separate experiments, in the presence or absence of a glutathione S-transferase (NBD-Cl 1x: 270 g ai ha^{-1}) and a cytochrome P450 (malathion 1x: 2000 g ai ha^{-1}) enzyme-inhibitors. The A82 accession was used as a control for 2,4-D, atrazine, and mesotrione; and the A106 accession (F1 generation of A82) for glyphosate. The GST- and P450-inhibitor were applied 48h and 1h before the herbicide treatment, respectively. After herbicide application, plants were placed in two growth chambers set to two temperature regimes: ambient (14/27°C min/max) and elevated (19/32°C). At 21 DAT, aboveground biomass was harvested. Data were converted into percent biomass compared to their respective non-treated control. For A101, the 2,4-D ED_{50} was smaller at elevated than ambient temperatures [176.7 (±27.1) and 255.5 (±36.6) g ae ha^{-1}, respectively], and both GST- and P450-inhibitors reduced the 2,4-D ED_{50} for A101 by 53% at ambient temperatures [120.3 (±18.9) and 121.3 (±23.3) g ae ha^{-1}, respectively]. For A82, the 2,4-D ED_{50} did not differ between elevated and ambient temperatures. For both A82 and A101, the ED_{50} for atrazine was greater at elevated [328.5 (±66.1) and 563.3 (±114.0) g ai ha^{-1}, respectively] than ambient temperatures [88.4 (±20.9) and 189.2 (±58.2) g ai ha^{-1}, respectively], and GST-inhibitor reduced the atrazine ED_{50} for A101 by 43% at elevated temperatures [319.7 (±84.6) g ai ha^{-1}]. For both A82 and A101, the ED_{50} for mesotrione was greater at elevated [3.8 (±0.6) and 4.7 (±0.8) g ai ha^{-1}, respectively] than ambient temperatures [0.7 (±0.3) and 2.3 (±0.5) g ai ha^{-1}, respectively]. The GST-inhibitor reduced the mesotrione ED_{50} for A101 by 34% at elevated temperatures [3.1 (±0.6) g ai ha^{-1}] whereas the P450-inhibitor reduced the mesotrione ED_{50} for A101 by 52% at ambient temperatures [1.1 (±0.4) g ai ha^{-1}]. For both A106 and A101, the glyphosate ED_{50} did not differ between elevated [196.5 (±29.0) and 756.9 (±252.2) g ai ha^{-1}, respectively] and ambient temperatures [148.5 (±22.1) and 573.3 (±150.3) g ai ha^{-1}, respectively], and neither enzyme-inhibitor reduced the glyphosate ED_{50} for A101 at either temperature regime. Our results suggest that elevated temperatures increased the expression of atrazine and mesotrione metabolic resistance and reduced the expression of 2,4-D metabolic resistance in A101. Moreover, elevated temperatures increased the tolerance of A82 to atrazine and mesotrione. Glyphosate metabolic resistance expression was not affected by the different temperatures evaluated. Herbicide metabolic resistance severely threatens weed management sustainability, urging herbicide overreliance mitigation and integrated weed management.

Interaction of Pyridate versus Atrazine with HPPD-Inhibitors for Foliar Weed Control (87)

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Waterhemp (*Amaranthus tuberculatus*) continues to be a problematic weed that has evolved resistance to multiple herbicide mode of action groups. The use of multiple, effective herbicide modes of action in a tank mixture has been recommended to slow resistance evolution in waterhemp, which potentially allows growers to prolong the use of current herbicides. Synergistic herbicide interactions have been reported between photosystem II (PSII) and HPPD-inhibitors, most commonly for the herbicides atrazine plus mesotrione or tembotrione. Pyridate is also a PSII-inhibitor that has an alternative binding pocket than atrazine, but the interaction between pyridate and HPPD-inhibiting herbicides has not been fully investigated. Field experiments were conducted in 2024 to investigate the interaction between pyridate and HPPD-inhibitors on waterhemp compared to the same combinations with atrazine. The field trial was established in a non-crop area as a randomized complete block design with four replicates located in Lafayette, IN. Treatments consisted of pyridate, atrazine, mesotrione, tembotrione, pyridate or atrazine plus mesotrione, and pyridate or atrazine plus tembotrione. The interaction for combinations of with either mesotrione or tembotrione were synergistic at all evaluation timings. Control from pyridate, mesotrione, and tembotrione alone resulted in 0, 32, and 37% control, respectively, while the combinations of pyridate plus mesotrione and pyridate plus tembotrione resulted in 84 and 90% control by 28 DAT, respectively. At 28 DAT, pyridate mixed with HPPD-inhibitors had greater than 84% control while atrazine combined with HPPD-inhibitors had greater than 74% control. Biomass reduction data revealed no significant differences between herbicide combinations, with all treatments having greater than 92% biomass reduction. This research demonstrates that the combination of pyridate with mesotrione or tembotrione provides a synergistic herbicide interaction for the control of waterhemp. Furthermore, the combination of pyridate with mesotrione or tembotrione showed comparable efficacy to atrazine mixed with mesotrione or tembotrione, which suggests that pyridate could serve as an alternative chemical weed control option to atrazine when in a tank-mix with HPPD-inhibitors.

Evaluation of Transgenic Arabidopsis Expressing Lolium rigidum CYP81A10v7 for Multiple Herbicide Applications (88)

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Several cytochrome *P450* (CYP) genes are known to play role in evolution of metabolic resistance to herbicides in weeds. The *CYP81A10v7* was previously shown to confer metabolic resistance to five herbicide modes of action groups in a rigid ryegrass population. The objective of this research was to develop transgenic *Arabidopsis thaliana* plants expressing the *CYP81A10v7* gene (*LrCYP81A10v7*) and evaluate their response to multiple herbicide treatments. The wild type *Arabidopsis* plants were transformed using floral dip method to generate transgenic lines expressing *LrCYP81A10v7* as well as the reporter gene *eGFP* (vector control). PCR-positive *Arabidopsis* transgenic plants (T_1 generation) expressing *LrCYP81A10v7* and *eGFP* were selected to generate T_2 plants. Eight plants each of four T_2 lines (CYP 1 to 4), expressing *LrCYP81A10v7* and one vector control line were treated with 2,4-D at 280 g ae ha^{-1} (LD_{100}). Post application, visual injury percent was recorded at 4 weeks after treatment on a scale of 0-100 with 0 % for no injury and 100% for completely dead plants. The visual injury results showed that the *LrCYP81A10v7 Arabidopsis* lines survived the 2,4-D application with 98%, 94%, 82% and 73% visual injury respectively in lines CYP 1 to 4 while plants of *e*GFP line did not survive and exhibited 100% visual injury. Work is in progress to assess the response of the transgenic lines to other herbicide modes of action groups. The investigation will be insightful in understanding the role of *LrCYP81A10v7* gene in bestowing multiple herbicide resistance in other plant systems.

Does Glyphosate-Resistance in Giant Ragweed (*Ambrosia trifida*) Influence the Efficacy of Other Active Ingredients in a Tank-mix? (89)

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Herbicide-resistance in weeds, one of the most pressing concerns in modern agriculture, can manifest itself in many mechanisms, from metabolic resistance to rapid necrosis. A grower in western Ohio observed populations of giant ragweed (*Ambrosia trifida* L.) that had survived different burndown applications and suspected that a rapid necrosis glyphosate-resistant biotype was negatively influencing control efforts. This study examined two populations of giant ragweed for control by various tank-mixtures that did and did not include glyphosate. Population A was reported as a control failure from atrazine + s-metolachlor + mesotrione + bicyclopyrone + glyphosate. Population S was reported as a control failure from saflufenacil + atrazine + glyphosate. An experiment was initiated with these two populations of giant ragweed to evaluate control from different herbicide combinations to elucidate the control provided by these herbicide combinations. The giant ragweed seed was collected and stratified in damp sand for 8 weeks at 4°C. Seeds were treated with a 10% bleach solution and rinsed with water for 10 minutes before being placed in rolled germination paper and placed into a growth chamber. Germinated seeds were planted in soilless media. Treatments for population A included 1x labeled rate applications of glyphosate, atrazine, mesotrione, glyphosate + atrazine, glyphosate + mesotrione, atrazine + mesotrione, glyphosate + atrazine + mesotrione + bicyclopyrone, and an untreated control. Treatments for population S included 1x labeled rate applications of glyphosate, atrazine, saflufenacil, glyphosate + atrazine, glyphosate + saflufenacil, atrazine + saflufenacil, glyphosate + atrazine + saflufenacil, and an untreated control. These populations were sprayed with a single-nozzle track spray chamber and control ratings (%) were taken at 14 and 21 days after treatment (DAT). The trial was terminated 21 DAT and plants were harvested at the soil surface, dried down at 60°C for three days, and weighed to collect biomass data. This data was analyzed to assess control efficacy and examine trends. For population A, there was no difference in herbicide treatments, with or without the inclusion of glyphosate at 14 or 21 DAT, other than glyphosate alone and the untreated control which had reduced control. The biomass of plants in population A was greatest for the untreated, followed by glyphosate, then followed by the rest of the treatment groups, which were not significantly different than each other. There were similar responses observed with population S. Although both populations had characteristics that suggested the rapid response resistance trait to glyphosate, the results of this study suggest that this likely did not result in the control failures observed in the field.

Differential Response of *Ipomoea hederacea* Jacq. to Glyphosate and Dicamba (90)

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Plants from the Convolvulaceae family, such as *Ipomoea hederacea* Jacq., exhibit some level of natural tolerance to glyphosate, complicating control efforts where glyphosate is widely used. This tolerance also makes *I. hederacea* prone to a hormetic response, by increasing biomass production when exposed to glyphosate doses that typically control other weed species. This greenhouse study evaluated the response of *I. hederacea* to glyphosate and dicamba. At the BBCH 12 stage (2 true leaves), plants were exposed to glyphosate doses of 0, 449.4, 898.9, 1796.5, 2310, and 2887.5 g ae ha^{-1} and dicamba doses of 0, 0.112, 0.56, 1.12, 5.6, 56, and 560 g ae ha^{-1}. Visual control (0-100%) was recorded 28 days after treatment, along with measurements of dry matter and leaf area. The estimated effective dose for 50% visual control with dicamba was 73.8 (±2.1) g ae ha^{-1} and 98.5 (±5.7) g ae ha^{-1} for a 50% reduction in dry matter. With glyphosate, 50% visual control required 2224.7 (±35.8) g ae ha^{-1} and a 50% reduction in dry matter required 2159.1 (±104.28) g ae ha^{-1}. Additionally, glyphosate doses between 224.7 and 898.8 g ae ha^{-1} induced a hormetic response, increasing biomass, with a hormesis parameter f of 0.31 ($p < 0.01$), while dicamba did not elicit such response. These results indicate that *I. hederacea* is much more sensitive to dicamba than glyphosate, requiring approximately 13 and 17% of the dicamba label rate to achieve comparable visual control and dry matter reduction, compared to 165 and 160% of the glyphosate label rate for similar effects. The study highlights *I. hederacea* differential response to these herbicides and the need for species-specific herbicide management programs.

Updated HRAC Mode of Action Classification (91)

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Herbicides are a diverse group of chemical structures which inhibit normal plant processes. This diversity is represented by their chemical structures, physio-chemical features, and ultimately their effect on the plant. In the past, there has been attempts at classifying a herbicide based on their mode of action (MoA). These attempts have led to the creation of classification schemes, one of which is represented on the accompanying poster. Additionally, the classification of some herbicides has changed over time, requiring an update to the weed science community and the public at-large. The United States Herbicide Resistance Action Committee (US HRAC) aligns with the Global HRAC classification scheme, and several herbicides have re-classified MoAs in the past year. This poster is freely available to the public, and high-resolution files can be found and downloaded at https://hracglobal.com/tools/2024-hrac-global-herbicide-moa-classification.

Physiological Basis of Corn Injury to Mesotrione under High-Temperature Stress (92)

Yasir Nazir Parrey*[1], Mithila Jugulam[2], P.V. Vara Prasad[1]
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Corn is naturally tolerant to the herbicide, mesotrione due to metabolism of this herbicide via activity of cytochrome P450 enzymes. Previous studies suggested that high temperature (HT) stress causes mesotrione injury in corn. This study aimed to assess the physiological basis of increased corn injury to mesotrione under HT stress. Cytochrome P450 enzyme inhibitor assay was conducted using malathion to assess their role in mesotrione metabolism. Corn plants were grown in growth chamber initially maintained at optimum temperature (OT: 30/25 °C day/night), and some plants at 3-4 leaf stage were shifted three days before herbicide treatment to a second growth chamber maintained at HT (40/35°C day/night), for acclimatization. Following this, the plants were treated with mesotrione (210 and 420 g ai ha^{-1}) alone or combination of mesotrione and malathion (2000 and 4000 g ai ha^{-1}). The experiment was conducted twice in randomized complete block design with four replicates in each treatment. Further, to determine the pattern of mesotrione metabolism, fourth youngest leaf of corn plants grown at above conditions was treated with 100,000 dpm of [phenyl-U-14C]-mesotrione along with necessary adjuvants (AMS 1% w/v and COC 1% v/v). Whole plant parts along with the treated leaf was harvested at 6 and 24 hours after treatment to assess the absorption, translocation, and metabolism of mesotrione. There was a significant reduction in biomass accumulation in corn plants treated with malathion followed by mesotrione at HT, suggesting increased injury in corn at HT most likely due to reduced activity of P450 enzymes, thereby decreased mesotrione metabolism. Metabolic analysis of mesotrione using HPLC is in progress. This research will help understand the physiological basis of reduced mesotrione metabolism in corn at HT, emphasizing the need for strategies to mitigate such herbicide injury.

Unraveling the Genetic and Molecular Changes Associated with Clopyralid Resistance in Common Ragweed (*Ambrosia artemisiifolia*) (93)

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Ambrosia artemisiifolia (common ragweed) is a widespread and challenging weed that can significantly reduce crop yields if not managed effectively. In 2018 a population of common ragweed was identified on a Michigan Christmas tree farm that exhibited high levels of resistance to clopyralid. The population has been shown to survive doses 32 times the recommended field rate. Chemical weed control remains the cornerstone management tactic in agricultural systems throughout the United States thus herbicide resistance threatens its efficacy. Understanding the mechanisms behind herbicide resistance and how herbicide resistance evolves in agricultural production systems is crucial to maintain chemical weed control as a viable option for farmers. Therefore, we created an experiment to analyze gene expression in clopyralid resistant and susceptible common ragweed populations using RNA-seq. The differential gene expression test found 70 genes with a log fold change greater than ±2 and a p-value ≤0.01. There were 39 genes that had a higher expression in the resistant population and 31 genes that had a higher expression in the susceptible population. The experiment revealed two genes associated with auxin: CYP83B1, a cytochrome P450 and RAP2-3, an ethylene response transcription factor. In addition, we evaluated growth performance of these resistant and susceptible biotypes in a greenhouse study. The study followed a randomized complete block design with four replications and two runs. Factorial combinations consisted of biotype (clopyralid resistant or susceptible), nitrogen level (low-0 kg N ha^{-1}, medium-112 kg N ha^{-1}, or high-224 kg N ha^{-1}), non-lethal herbicide dose presence or absence (0.105 kg a.i. ha^{-1} or 0 kg a.i. ha^{-1}), and soil moisture (ambient-100% field capacity or reduced-50% field capacity). The following measurements were taken every three weeks for the duration of the experiment: photosynthetic output (quantum yield of photosystem II (Phi2), quantum yield of non-photochemical quenching (PhiNPQ), quantum yield of other unregulated losses (PhiNO), and relative chlorophyll (RC)), plant height, and leaf number. Plant maturation rates were assessed by measuring days after emergence to the appearance of buds and production of pollen. Finally, plant biomass was weighed after plant senescence and seeds were collected. Data were analyzed using linear mixed-effects models in R and means were separated using Tukey's HSD. Data were combined across years. The greenhouse experiment found that the number of leaves at 6 weeks, rate of maturity, seed number, and seed weight were impacted by biotype ($p<0.001$, $p<0.001$, $p=0.017$, $p=0.049$). The resistant biotype had 32% more leaves than the susceptible biotype when measured at 6 weeks after treatment averaged across nitrogen, herbicide, and soil moisture treatments. The resistant biotype started to produce pollen 20 days faster than the susceptible biotype averaged across nitrogen, herbicide, and soil moisture treatments. The resistant biotype produced 24% more seeds with the resistant biotype producing 2,303 seeds $plant^{-1}$ while the susceptible biotype produced 1,854 seeds $plant^{-1}$ averaged across herbicide, nitrogen, and soil moisture treatments. In conclusion, it is critical to understand how gene and transcript abundance affect overall plant productivity in resistant weed biotypes.

Exploring the Genetic Basis of Spine Evolution in *Amaranthus* (94)

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Spines, thorns, and prickles represent a range of defensive structures co-evolved in many plants to deter herbivory and survive in diverse environments. Though these structures often serve similar functions, they differ in evolutionary origin: spines develop from leaf tissue and thorns from stem tissue, both containing vascular tissue, while prickles arise from epidermal or cortex tissue and lack vascular tissue. This morphological diversity is reflected in various weedy species, with spines in *Amaranthus spinosus* (spiny amaranth) and *Xanthium strumarium* (common cocklebur), thorns in *Cirsium vulgare* (common thistle), and prickles in *Rosa spp.* (roses) — each adapted to specific ecological niches. These structures complicate manual weeding in agriculture and deter livestock grazing, presenting a significant nuisance in crop fields. Despite their importance, the genetic basis for these adaptations remains largely unexplored. Research on *Solanum* species recently identified several independent mutations in conserved members of the LONELY GUY (LOG) gene family that regulate prickle development through gene co-option. However, the genetics of spine formation, particularly in weedy species, is still unknown. *A. spinosus* offers a valuable model for studying spines, as it is one of the few *Amaranthus* species to develop these structures and is known for its persistence as a troublesome agricultural weed. Focusing on this species allows us to explore the genetic basis of spine formation and gain insights applicable to weed management. Our study investigates the genetic mechanisms behind spine development in *Amaranthus* by evaluating interspecific crosses between non-spiny *Amaranthus palmeri* (Palmer amaranth) and *A. spinosus*. Using a genetic mapping approach that integrates high-throughput sequencing with phenotypic analysis of segregating populations, we aim to identify key loci associated with spine traits. Comparative analysis across *Amaranthus* species will further examine synteny and gene polymorphisms within this genus. Ultimately, this work has the potential to identify genetic targets that could help manage spiny traits, with applications in breeding and weed management.

Pennycress Response to Soybean Herbicide Carryover (95)

Mark Bernards*[1], Gregg Johnson[2]
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Pennycress (*Thlaspi arvense*) is undergoing domestication and varieties are being developed for its adoption as an intermediate oilseed crop in the U.S. Corn Belt. Golden-seeded pennycress varieties are non-dormant, have low erucic acid content and increased seed oil compared to dark-seeded, wild-type pennycress. Pennycress is planted in the fall and forms a rosette that overwinters, protecting the soil from erosion and reducing nitrogen leaching. In the early spring, it bolts and flowers, producing seed by late spring, which allows a second crop to be grown and harvested in the fall. Soybean may be a desirable crop to precede pennycress because there is less residue to interfere with pennycress emergence compared to grain corn. However, little is known about how pennycress may be affected by carryover of herbicides commonly used in soybean. Field studies were conducted 2023-2024 in Waseca and Morris, Minnesota, to measure the effect of soybean herbicide carryover on pennycress stand and yield. Soybean herbicides were applied preemergence at twice the labeled rate immediately after soybean planting. Golden-seeded pennycress (ARV1-TT8T) was seeded Sept 19 (Waseca) and Sept 22 (Morris). Pennycress stand, visual injury, canopy cover, winter survival and seed yield were measured. No treatment differences were observed in Waseca. In Morris, pennycress showed no injury or yield loss from metribuzin or saflufenacil applied in the previous soybean crop. Severe injury, reduced winter survival and reduced pennycress yield was observed in all treatments where cloransulam-methyl, chlorimuron-ethyl, and imazethapyr (WSSA Group 2) were applied singly or as part of an herbicide pre-mixture. Fomesafen-containing herbicides injured pennycress but did not reduce yield. Visual injury ratings of pennycress exceeded 40% for herbicides containing sulfentrazone and flumioxazin, but not all treatments caused yield loss. Weather in Morris between herbicide application and pennycress planting was warmer and drier than normal, which may have reduced microbial degradation. Individuals considering planting pennycress after soybean should avoid the use of herbicides containing cloransulam, chlorimuron, imazethapyr, sulfentrazone, flumioxazin and fomesafen.

General Session

Welcome to the 79th Annual Meeting of the North Central Weed Science Society (96)

Mark Bernards*
USDA-ARS, Morris, MN

No abstract submitted.

Welcome to Kansas City (97)

No abstract submitted.

Harry S. Truman: The Farmer President (98)

Samuel (Sam) Rushay*
US National Archives and Records Administration, Harry S. Truman Library and Museum, Independence, MO

No abstract submitted.

Washington, D.C., Science Policy Update (99)

Lee Van Wychen*

Weed Science Society of America, Alexandria, VA

No abstract submitted.

Presidential Address (100)

Dawn Refsell*
Corteva Agriscience, Johnston, IA

No abstract submitted.

NCWSS Finance Update (101)

Eric Spandl*
Winfield United, River Falls, WI

No abstract submitted.

Remembering NCWSS Members and Friends (102)

Brett Lynn*
Bayer Crop Science, Creve Coeur, MO

No abstract submitted.

Program Announcements (103)

Mark Bernards*
USDA-ARS, Morris, MN

No abstract submitted.

Oral 1 – Student Contest - Weed Genetics and Herbicide Physiology; Weed Biology and Ecology; Row Crop Herbicides; Cover Crops and IWM

Development and Application of KASP Assays for Differentiating Between *Sorghum bicolor* x *halepense* Biotypes (104)

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Johnsongrass (*Sorghum halepense*) is a troublesome weed that causes immense environmental and economic damage worldwide. Cultivated sorghum, or shattercane (*Sorghum bicolor*), is a progenitor of johnsongrass that is both domesticated and a weed. Hybridization between *S. bicolor* and *S. propinquum* formed the tetraploid johnsongrass, thereby enhancing its genetic diversity. Unfortunately, these species continue to be able to hybridize, causing difficulty in identification and management. Proper identification is vital for effective weed management. Moreover, it is important to track hybridization between species to follow herbicide resistance geneflow and overall evolution of the species. For this reason, the objectives of this study were to create a simple genetic method to accurately differentiate between *S. bicolor*, *S. halepense*, and their respective hybrids- for this we turned to kompetitive allele specific PCR (KASP). KASP is primarily used to distinguish two samples at a single nucleotide polymorphism (SNP). *S. bicolor* and *S. halepense* are consistently different at a single SNP in the internal transcribed spacer (ITS) region. Using this SNP, allele (species)-specific primers were designed, labelled with 5' fluor-labeled oligos of FAM (*S. bicolor*) or HEX (*S. halepense*). DNA was isolated from samples and normalized for the KASP assay. A cultivated sorghum line (Rtx430) and a known Michigan johnsongrass biotype were utilized as our *S. bicolor* and *S. halepense* positive controls, respectively. To validate our assay, primers were also designed to amplify the entire ITS region from both species. These PCR products were sent for Oxford Nanopore sequencing to compare nucleotide base counts at the diagnostic SNP position. Pearson's correlation was used to analyze the nucleotide base call between FAM/HEX (KASP) and 'C'/'T' (Oxford Nanopore). Our data suggests that we have provided a near perfect proxy for genotyping these hybrids through our KASP assay ($R2 = 0.97$, p-value = <0.001). Further, this assay is more cost-efficient than other genotyping methods ($0.17 vs. $15 per sample). The MSU johnsongrass collection consists of biotypes collected across 22 states including: Alabama, Arizona, California, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Kentucky, Maryland, Michigan, Nebraska, New York, Ohio, Pennsylvania, North and South Carolina, Tennessee, Texas, Virginia, and West Virginia. Utilizing this collection, 76 diverse johnsongrass biotypes were analyzed. Fifty-one percent were identified as homozygous *S. halepense*, 8% identified as homozygous *S. bicolor*, and 41% identified as a mixture of the two species. These biotypes did not form a distinct heterozygous cluster, instead forming a spectrum of intermediate genotypes that we theorize formed over years of hybridizing and backcrossing between individuals. Ongoing work consists of controlled crosses to access this hypothesis. Future work will aim to correlate the noted genotype with known phenotypic traits across the two species.

Characterization of the Interaction of Pyridate and HPPD-Inhibitors for Improved Weed Management (105)

Grant Isaacs*, Julie Young, Bryan Young
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Amaranthus species have been reported to be resistant to atrazine through target site mutations at the D1 Serine 264 binding site in photosystem II (PSII) and non-target site (metabolism) based mechanisms. Pyridate is a PSII inhibitor that is labeled for use in corn production and has different binding characteristics in PSII than atrazine, which should not be impacted by the atrazine resistance mechanisms. Previous research documented a synergistic interaction between photosystem II (PSII) inhibitors and hydroxyphenylpyruvate dioxygenase (HPPD) inhibitors, such as atrazine and mesotrione. However, there is limited research that investigates the herbicide interaction between pyridate and HPPD-inhibiting herbicides. Therefore, this study was initiated to characterize the interaction between pyridate and HPPD-inhibitors. Greenhouse and field experiments were conducted in 2024 to identify the interaction between pyridate and mesotrione or tembotrione on an atrazine-sensitive waterhemp population, a target site atrazine-resistant waterhemp population, and a Palmer amaranth (*Amaranthus palmeri*) population sensitive to atrazine (field only). In greenhouse experiments, a synergistic interaction was observed from combinations of pyridate with mesotrione or tembotrione for visual control and fresh weight reductions. In the field, a synergistic interaction was observed for the atrazine-sensitive population for pyridate plus mesotrione (84% control) and pyridate plus tembotrione (90% control) by 28 DAT, while pyridate, mesotrione, and tembotrione alone resulted in 0, 32, and 37% control, respectively. Additive herbicide interactions were observed more often than synergistic interactions between pyridate and HPPD-inhibitors for the atrazine-resistant population, but provided adequate weed control of atrazine-resistant waterhemp with visual control estimates greater than 91% by 28 DAT. Combinations of pyridate plus mesotrione (86% control) and pyridate plus tembotrione (97% control) were synergistic by 28 DAT for the Palmer amaranth population, whereas pyridate, mesotrione, and tembotrione alone resulted in 7, 37, and 88% control, respectively. This research indicates that pyridate can result in synergistic responses when combined with mesotrione or tembotrione on *Amaranthus* species, while also providing adequate control of atrazine-resistant waterhemp. Combining pyridate with mesotrione or tembotrione may help growers increase the control of problematic *Amaranthus* species.

Harnessing the Power of Hormesis: Fact or Fiction? (106)

Luka Milosevic*, Jon Scott, Amit Jhala, Stevan Knezevic
University of Nebraska-Lincoln, Lincoln, NE

According to the UN World Population Prospects, global population is expected to reach 9.7 billion by 2050. Additionally, the U.S. Department of Agriculture Economic Research Service predicts that 47% more food will be needed to meet the growing demand. This increasing need for food, combined with limited resources, indicates the need for alternative strategies to ensure global food security. One potential solution is hormesis, a well-documented biphasic dose-response phenomenon where organisms benefit from the exposure to low doses of otherwise harmful agents. To explore this concept, two sets of field experiments were conducted at the University of Nebraska-Lincoln. The first experiment evaluated whether sublethal doses of dicamba induce hormesis in sensitive soybean. Plants were exposed at three different growth stages (V2, R1, and R2) to a range of 10 dicamba doses (0, 0.0112, 0.014, 0.019, 0.028, 0.056, 0.112, 0.56, 5.6, and 56 g ae ha^{-1}). In the second experiment, sensitive soybeans were exposed to sublethal doses of glyphosate (0, 2, 6, 18, 54, 162, and 324 g ae ha^{-1}) at V2, R1, and R3 growth stages. Plant biomass was measured 28 days after treatment (DAT), and soybeans were hand-harvested at physiological maturity to estimate grain yield. Regression analyses were performed using the drc package in the R software environment. Fitting various hormesis models to the data indicated that dicamba did not induce hormesis in soybeans, as no significant increase in dry matter or yield was observed. The hormesis parameter (f) was either estimated to be negative or not significantly different from zero (p-value > 0.05). In contrast, low doses of glyphosate did increase soybean dry matter when applied at the V2 and R1 growth stages, with the hormesis parameter (f) estimated at 0.72 (p-value > 0.05) and 0.34 (p-value > 0.05), respectively. However, this increase in dry matter did not translate into a higher harvestable yield. While no enhancement in yield was observed, the findings confirm the reproducibility of hormesis effects under field conditions. Further research is needed to identify the specific agents, doses, and yield controlling genes in various crops that may lead to an increase in harvestable yield.

Differentiating Soybean Response from Two Classes of Bleaching Herbicides: An Opportunity for Phenotyping Technology (107)

Abigail Norsworthy*, Zhongzhong Niu, Jian Jin, Thomas Butts, Julie Young, Bryan Young
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Diflufenican, a phytoene desaturase inhibiting herbicide, is being developed for soil residual weed control prior to crop emergence and represents a new herbicide mode of action group (HRAC Group 12) for use in US soybean production. Plant tissue sensitive to diflufenican develops similar symptomology to HRAC Group 27 herbicides. More specifically, soil persistence of mesotrione applied in corn and carryover to subsequent soybean can exhibit similar soybean injury as diflufenican. Therefore, determining if soybean bleaching injury originates from diflufenican applied for soybean weed management or from potential mesotrione carryover may be problematic. Two field experiments were conducted using a randomized complete block design with four replications, with treatments including diflufenican (150 and 300 g ai ha^{-1}), mesotrione (26.25 g ai ha^{-1}), and combinations of diflufenican plus mesotrione. The application rate of mesotrione was designed to simulate carryover from a corn application in the previous year. Visual assessments of crop injury were conducted at 14, 21, 28, and 35 days after application (DAA). Soybean leaves were collected at 26 DAA and scanned with a line-scanning hyperspectral leaf scanner (LeafSpec). Leaf image segmentation was achieved with a one-dimensional convolution to enhance plant tissue contrast, followed by Savitzky-Golay smoothing to reduce noise. A partial least squares model was used for image classification, resulting in confusion matrices for each run. Colby's method was used to characterize the interaction between diflufenican and mesotrione based on visual data. At 28 DAA in the first trial, visual soybean injury from diflufenican (150 g ha^{-1}) was 7%, mesotrione was 6%, and the combination of the herbicides was synergistic with 19% soybean injury. The hyperspectral scanner demonstrated an accuracy of 93% in the first run and 84% in the second run when classifying unique soybean leaf response into the three treatment categories (diflufenican, mesotrione, and mesotrione + diflufenican). These findings suggest that distinguishing between herbicides with similar injury symptomology is feasible at the spectral level.

Multiple Herbicide Resistance in *Poa annua* is Mediated by Cytochrome P450 (108)

Mohit Mahey*[1], Eric Patterson[1], Peter Lundquist[1], Jinyi Chen[2];
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Poa annua is an annual weed in southern USA turf fields. Resistance cases towards multiple herbicides with different modes of action has been reported and is becoming a serious problem. Indaziflam, a cellulose biosynthesis inhibitor herbicide is a good option to control this weed, however recently, resistant populations were reported. We performed an RNA-seq, comparing three susceptible and resistant populations to find candidate genes that might be metabolizing the herbicide. The transcriptome data were analyzed through differential gene expression (DGE) and weighted correlation network analysis (WGCNA). We found the group of genes that are positively correlated (0.97) with resistance phenotype. We have identified a cytochrome P450 that is very similar to *CYP81A10* reported to confer resistance to five different herbicide modes of action in *Lolium rigidium*. The multiple herbicides were screened for resistance in *P. annua* populations in combination with malathion (CYP-450 enzyme inhibitor). Application of malathion causes resistance reversal for three difference herbicides, signifying involvement of CYP-based metabolism. We hypothesize that the cytochrome P450 up regulation is associated with indaziflam resistance, and potentially conferring resistance to other herbicides. Heterologous transformation of the CYP to *Arabidopsis thaliana* has been done for validation of hypothesis. The results will give insights to better understand herbicide resistance and its regulation.

The Nexus Between Reactive Oxygen Species and the Mechanism of Action of Herbicides (110)

Catherine Traxler*[1], Todd Gaines[1], Anita Kuepper[2], Peter Luemmen[3], Franck Dayan[1]
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No abstract submitted.

Documenting the Extent of Resistance to Group 15 Herbicides in Illinois Waterhemp (*Amaranthus tuberculatus*) (111)

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Two populations of waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] in Illinois have been confirmed resistant to Group 15 (VLCFA-inhibiting) herbicides. These populations displayed non-target-site resistance via rapid herbicide metabolism. VLCFA-inhibiting herbicides are used throughout Illinois for residual preemergence (PRE) control of small-seeded dicot and grass weeds in multiple crops. Residual control of waterhemp is essential due to prolonged emergence in a growing season. Relative to other sites of action, resistance to VLCFA-inhibiting herbicides is less frequent and occurs in only a few species. Waterhemp has become resistant to herbicides from multiple sites of action, including many postemergence (POST) herbicides. As herbicide resistance in waterhemp has increased over time, utilization of VLCFA-inhibiting herbicides has increased. The objective of this study is to determine the extent of VLCFA-inhibitor resistance in waterhemp across the crop producing areas of Illinois. During fall 2023, female waterhemp inflorescences were collected from 127 random soybean fields across 84 of Illinois' 102 counties. In addition to random collections, submissions were accepted from the public with an emphasis on fields in which resistance is suspected. *S*-metolachlor was selected for greenhouse screening based on previous dose-response experiments with the two Group 15-resistant populations. In those experiments, the highest resistant:sensitive (R:S) ratio occurred with *S*-metolachlor relative to the other VLCFA-inhibiting herbicides evaluated. A discriminating dose was selected by evaluating increasing doses of *S*-metolachlor among the progeny of a resistant population, two public submissions showing putative resistance, and three samples with various degrees of sensitivity. Samples were screened in the greenhouse by spraying with a single-nozzle research sprayer shortly after planting into a greenhouse soil. Applications were incorporated by use of an overhead misting station. In addition to the discriminating dose, a nontreated control was included to obtain a germination percentage of each population. The two treatments allow a survival percentage to be calculated, as well as an evaluation of growth reduction 10 days after application. The progeny of a confirmed-resistant population has shown 45% survival at the discriminating dose. To date, 45 unique populations have been screened. Twenty samples have higher survival than that of the confirmed resistant population. Ten, 7, and 2 populations have survival rates above 70, 80, and 90%, respectively. Remaining screenings and dose-response experiments are underway to further quantify the extent and magnitude of resistance.

Shedding Light on Weed Seed Germination: The Role of Light Quality and Incubation Period (112)

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Seed germination can be influenced by several factors including light, temperature, and their fluctuations. Experiments were conducted in 2024 using the growth chambers at the University of Minnesota to determine the effect of light quality, seed incubation environments, and the incubation period after maturity on the germination of five weed species: giant ragweed (*Ambrosia trifida* L.), Palmer amaranth (*Amaranthus palmeri* S. Watson), waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer], common lambsquarters (*Chenopodium album* L.), and common ragweed (*Ambrosia artemisiifolia* L.). Light quality treatments included red:far-red ratios of 1.2

(representing full sunlight), 0.6 (partial sunlight or shading), and 0 (dark). Seed incubation environments included two factors: soil-buried seeds with fluctuated temperature starting in November and refrigerator-stored seeds at a constant temperature of 4 ℃. Seeds were retrieved at 0, 1, 2, 4, and 6 months after incubation. Results showed that the full sunlight treatment showed a greater germination of all the weed species compared to shading and dark. Both soil incubation and refrigeration showed an increasing trend in germination over time, with seeds that were incubated in soil resulting in 10 to 15% higher germination depending on the weed species compared to seeds in refrigeration at 6 months retrieval. The results of this experiment showed that shading could negatively impact weed seed germination regardless of the species, and the incubation conditions that offered fluctuating temperatures and other conditions helped overcome seed dormancy more rapidly than in a controlled environment. Additionally, a longer incubation period after maturity can positively influence weed seed germination.

Effects of Soil Texture and pH on Level of Soybean (*Glycine max*) Injury to Sulfentrazone and Chlorimuron (113)

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The importance of including pre-emergence herbicides in soybean production has been increased by weed resistance to many post-emergence herbicide options. Pre-emergence herbicides like sulfentrazone and chlorimuron, commonly used in soybeans, can cause phytotoxic crop injury effects under certain soil conditions. The objective of this study was to investigate the influence of soil cation exchange capacity (CEC), pH, and herbicide rate on soybean growth and biomass. The soil was collected from the Kansas State University North Farm near Manhattan, KS (initial pH = 6, CEC = 19 meq 100 g^{-1}) and amended with hydrated lime to adjust pH and amended with sand to adjust CEC, based on preliminary studies that determined optimal ratios. Hydrated lime was mixed with air-dried soil in a cement mixer for 15 minutes, then the soil was placed in large plastic trays, watered, and left to dry. After four months of weekly pH measurements, the pH stabilized at desired levels. Soils with pH levels of 6.0, 6.7, and 7.3 were mixed with 0, 20, 40, or 60% sand to achieve one of four target CEC levels (9, 13, 17, and 19 meq 100 g^{-1}). The experimental design was completely randomized and had a factorial arrangement of 3 pH levels, 4 CEC levels, 2 herbicides, and 4 rates, with five replications and two experimental runs. Four soybean seeds were planted per pot (6x6x6.5 cm) under greenhouse conditions. Pots were treated with sulfentrazone (1X = 280 g ha^{-1}) or chlorimuron (1X = 53 g ha^{-1}) at rates of 0, 0.5X, 1X (field rate), and 2X. Visual plant injury was assessed at 7, 14, and 21 days after treatment (DAT) on a 0 to 100% scale, where 0% indicated no injury relative to nontreated controls and 100% indicated plant death. Above-ground biomass was harvested 21 DAT. For chlorimuron, soil texture and herbicide rate were the factors that most influenced biomass. Significant interactions between pH and texture and between texture and rate, suggest that soil texture modified the effect of pH and herbicide rate on biomass. For sulfentrazone, soil texture had a significant effect on biomass, and herbicide rate also affected biomass. Significant interactions between pH and texture and texture and rate imply that the effectiveness of herbicide rates was influenced by the soil's pH and texture. Furthermore, the interaction between pH and rate highlights that the response to herbicide application can change with pH levels, suggesting that pH management could play a role in optimizing herbicide efficacy. Overall, these results demonstrate that variations in soil conditions have major effects on the potential of pre-emergent herbicides to cause soybean injury. As pre-emergent herbicides continue to be a critical component for weed management, more information about these soil–herbicide interactions will be essential to reducing crop injury.

Emergence Periodicity of Six Weed Species as Impacted by Cereal Rye (*Secale cereale* L.) Cover Crop in the Upper Midwest (114)

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Weed seedling emergence is impacted by factors such as soil temperature, soil moisture, and exposure to light. Cover crops have gained interest for weed management because they can influence these factors, ultimately enhancing weed suppression. The objective of this research was to assess the impact of cereal rye (*Secale cereale* L.) cover crop on emergence patterns of six weed species commonly found in the Midwest, including: common lambsquarters (*Chenopodium album* L.), common ragweed (*Ambrosia artemisiifolia* L.), giant ragweed (*Ambrosia trifida* L.), horseweed (*Erigeron canadensis* L.), waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer], and woolly cupgrass [*Eriochloa villosa* (Thunb.) Kunth]. Field studies were conducted from 2021 to 2023 in MN. Cereal rye cover crop drilled at 67 kg ha^{-1} in the fall were compared with no cover crop treatment in soybean (*Glycine max* L.). Weed seeds were hand-broadcasted after cover crop planting in designated strips. The Soil Temperature and Moisture Model (STM^2) was used to predict annual soil temperature and moisture profiles, and cumulative weed emergence, and cumulative hydrothermal time (HTT) was modeled using the Weibull function. Our study found that cover crops influenced emergence patterns and cumulative seedling emergence; however, it was species and year-dependent. Cover crop reduced the cumulative emergence of four broadleaf species including common lambsquarters, common ragweed, giant ragweed, and waterhemp, but the cumulative emergence of only grass species (woolly cupgrass) tested in this research was not impacted. The results of this research highlighted the importance of incorporating cereal rye cover crops for effective broadleaf weed control in soybean.

Crop Safety from Encapsulated Saflufenacil + Pyroxasulfone Combinations Applied Postemergence in Corn (115)

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Saflufenacil lacks selectivity to crops in foliar applications, which has limited the potential use of saflufenacil for added soil residual weed control from applications later in the season. A microencapsulated saflufenacil formulation has been registered for use in corn to increase the crop selectivity of saflufenacil by limiting foliar absorption. The microencapsulated formulation is a premixture with pyroxasulfone and is labeled for preemergence through early postemergence applications in corn. Trace levels of free (unencapsulated) saflufenacil in the premixture are possible and may cause significant foliar phytotoxicity when tank-mixed with specific herbicides and adjuvants. Field and greenhouse experiments were conducted at Purdue University to quantify corn response from the addition of other herbicides and adjuvants in tank mixture with the encapsulated premixture when applied postemergence in corn. Herbicide treatments included the encapsulated saflufenacil + pyroxasulfone premixture applied with different activator adjuvants, nitrogen sources, and foliar active herbicides. Applications were made at the V3 corn growth stage with a handheld boom equipped with XR10002 nozzles calibrated to deliver 140 L ha^{-1} at 207 kPa. In the field, leaf necrosis at 3 days after application (DAA) ranged from 2 to 30%, with treatments containing methylated seed oil (MSO) having the most necrosis. Additionally, treatments containing crop oil concentrate (COC), high surfactant oil concentrates (HSOC), or glufosinate resulted in greater than 10% necrosis compared to 2% necrosis that resulted from applying the encapsulated saflufenacil + pyroxasulfone premixture alone. The activator adjuvants applied with urea ammonium nitrate (UAN, 2.5% v/v) as a nitrogen source resulted in less leaf necrosis than the adjuvant treatments with ammonium sulfate (AMS, 5% v/v). By 14 DAA, leaf necrosis dissipated and was less than 10% for all treatments. The modified chlorophyll absorption in reflectance index (MCARI) was calculated from multispectral drone images collected at 4 and 14 DAA. MCARI values followed similar trends to visual injury with the most injurious treatments causing MCARI reductions. Greenhouse experiments confirmed the field results with the MSO treatments causing the most corn leaf necrosis. This research demonstrates that early postemergence applications of the encapsulated saflufenacil + pyroxasulfone premixture may result in temporary corn injury, but careful management of other chemicals applied in mixture may be necessary to limit the extent of crop response. Additionally, this research supports that multispectral imaging indices, such as MCARI, can be used as a quantitative measure of transient herbicide injury, such as that observed with encapsulated saflufenacil.

Optimizing Soybean Canopy Growth: The Impact of Planting Date and Variety Selection (116)

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The weed-suppressing ability of cultivated crops is often underestimated in annual row cropping systems. Canopy coverage plays a crucial role in weed suppression and is influenced by various agronomic practices. The planting time and variety selection are among the key factors that influence canopy development. Field experiments were conducted in 2023 and 2024 at the Rosemount Research and Outreach Center near Rosemount, MN, using a split-plot design to evaluate the effects of soybean variety selection and planting date on canopy formation, weed suppression, and yield. Main plot factors included four commercially available soybean varieties with distinct growth habits: two short and bushy types (XO1822 E and XO1966 E) and two tall and slender types (CZ1660GTLL and 18A73 E). Subplot factors included three planting dates:

early (early May), mid (mid-May), and late (early June). In 2023, at 21 days after POST herbicide application (DAP), variety XO 1822 E had the highest canopy cover (69%), whereas variety 18 A73 E had the lowest canopy cover (63%). Among the planting dates, early planted soybean recorded significantly higher (79%) canopy cover compared to late planting (48%) at that time. However, in 2024, at 21 DAP the canopy cover was similar among the four varieties and three planting dates. Whereas at 42 DAP, XO 1822 E showed the highest canopy cover (94%) and CZ 1660GTLL showed the lowest canopy cover (90%). Variety selection did not impact the total weed biomass. However, early planting date significantly reduced biomass of yellow foxtail (*Setaria pumila*) and common waterhemp (*Amaranthus tuberculatus*) (0.1g and 0.4g) compared to late planting (5g and 1.6g) in 2023. Soybean yield was not influenced by the variety selection, but early planting produced the highest yield (3,371 kg ha^{-1} in 2023 and 5,241 kg ha^{-1} in 2024) compared to late planting (2,895 kg ha^{-1} and 4,323 kg ha^{-1} in 2023 and 2024, respectively). Therefore, the selection of soybean varieties can influence the canopy closure, although no effect on yield was observed in this research. Planting soybean early (early May in this research) can improve soybean canopy development and yield.

Novel Preemergence Tank Mixtures Based on Synergistic Combinations Improve Control of *Amaranthus* Species in Maize Production (117)

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Palmer amaranth (*Amaranthus palmeri* S. Wats.) and waterhemp (*A. tuberculatus* (Moq) Sauer) are two problematic weed species in agricultural crop systems in the Midwestern U.S. These dioecious amaranths can reduce corn (*Zea mays* L.) and soybean (*Glycine max* (L.) Merr) grain yields up to 90% and 60%, respectively. Both *Amaranthus spp.* have developed resistance to multiple sites-of-action (SOA), and numerous multiple herbicide-resistant (MHR) populations have been confirmed. Herbicide programs that consist of a single SOA or rely solely on postemergence (POST) timings to control weeds are often ineffective, but tank-mix combinations utilizing new and unique SOAs provide a potentially effective strategy for weed control. Previous work indicated waterhemp and Palmer amaranth have developed resistance to common corn preemergence (PRE) herbicides, including inhibitors of very-long-chain fatty acid (VLCFA) synthesis, photosystem II (PSII; triazines), and 4-hydroxyphenylpyruvate dioxygenase (HPPD). Our objective was to design and test novel PRE tank mixes, including metribuzin and herbicides with other SOAs, to improve control of Palmer and waterhemp in field corn relative to current PRE herbicide options. Palmer- and waterhemp-infested fields in Urbana, IL were identified, and tank mix treatments were applied PRE in both locations. We hypothesized that metribuzin, a triazinone, could effectively replace atrazine within tank mixes, and the inclusion of a non-traditional herbicide SOA, phytoene desaturase (PDS; norflurazon), will improve or extend the effective period of weed control within these systems. Tank-mix partners included VLCFA, metribuzin, norflurazon, and HPPD-inhibiting herbicides. Various rates of metribuzin were added to tank mixes including HPPD inhibitors to evaluate interactions, based on previous work identifying synergistic effects. A post-emergence (POST) treatment consisting of glyphosate and

2,4-D applied 28 days after planting (DAP) was included to evaluate the impact of early-season weed control. Visual estimates of weed control and crop injury were collected every 7 days after treatment (DAT), with weed density counts recorded every 14 DAT up to 42 DAT. Crop yield data evaluated the impacts of weed control and crop injury. Visual estimates of weed control 42 DAT indicated labeled rates of individually applied herbicides resulted in 35-85% control, while tank mixes including two or more SOAs resulted in 78-96%. Results indicated norflurazon may improve residual control of *Amaranthus spp.*; however, this product resulted in excessive corn injury. Field data from 2024 indicates metribuzin in tank mixtures results in similar weed control to a current commercial product for corn applied alone. Untreated controls in 2023 and 2024 resulted in an average yield of 5.6 and 6.6 Mg ha^{-1}, respectively. Data indicated tank mix treatments resulted in an average yield increase of 15% Mg ha^{-1} compared to single herbicide treatments. One of the highest-producing treatments consisted of isoxaflutole (HPPD), metribuzin at 264 g ai ha^{-1} (PSII), and norflurazon (PDS). The POST treatment resulted in some of the highest-yielding plots, indicating weed pressure before 28 DAP did not significantly decrease yield. Our results indicate these novel tank mixes have potential for managing Palmer amaranth and waterhemp populations.

Oral 2 – Student Contest - Cover Crops and IWM; Row Crop Herbicides; Herbicide Application Technologies

Assessing Corn Residual Herbicide Effects on Early Season Interseeded Cover Crops (118)

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Cover crops have the potential to enhance soil organic matter and fertility, reduce erosion, minimize nutrient leaching, and suppress weeds. Consequently, they contribute to the improvement of soil health and the sustainability of agroecosystems. The advantages mentioned are inherently linked to the production of cover crop biomass. However, the growing season in Nebraska provides limited time for cover crop growth between harvest and establishment of a subsequent cash crop. Therefore, early-season drill interseeding is a potential solution, as it allows the cover crops a longer window for establishment and growth. The use of preemergence herbicides with soil residual activity is an important weed management practice in corn production, as they reduce early season weed emergence, weed-crop competition hence reducing yield loss. The residual effect of such herbicides can limit and even prevent the emergence and growth of cover crops, highlighting the importance of selecting an effective herbicide program for weed control yet compatible with early-season interseeded cover crops. An on-farm research experiment was conducted near Gothenburg, NE at the Bayer Water Utilization Learning Center to evaluate the effect of residual herbicides frequently used in corn on interseeded cover crops and common weed species. The main objectives of the study were: (1) to determine the best cover crop interseeding timing in corn; (2) evaluate potential carry-over effects from residual herbicides while maintaining effective weed control; (3) evaluate cover crop biomass production in short corn and in tall corn. Preemergence herbicide treatments were saflufenacil + dimethenamid, s-metolachlor

+ atrazine and acetochlor + atrazine. Post herbicides were glufosinate + glyphosate for all treatments, and a non-treated control. The cover crops consisted in a mix of cereal rye, winter wheat and annual rye were planted at 89.6 kg ha^{-1} seeding rate at V2, V4 and V6 corn growth stage and post-harvest. The aboveground biomass was collected 28 days after each planting time, and pre-harvest. Results showed that either saflufenacil + dimethenamid-P or acetochlor + atrazine impacted less on cover crop biomass production comparing with No-PRE herbicide applied (p-value <0.0001) when interseeding cover crops at V2 corn stage. Interseeding cover crops at V2 corn stage in short corn resulted in greater biomass production than in tall corn (p-value <0.0001).

The Effects of a Rye Cover Crop, Rye Termination Timing, and Herbicide Program on Waterhemp (*Amaranthus tuberculatus*) Control in a Corn-Soybean Rotation (119)

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In recent years, waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] has emerged as a problematic weed in Ohio agronomic crop production. Its adaptability, rapid proliferation, broad emergence window, and its resistance to multiple herbicides make waterhemp a major concern for weed scientists and producers alike. Waterhemp often causes significant yield losses in Ohio fields, underscoring the need for effective management strategies. This research project evaluates the control of waterhemp populations using three factors: 1) rye cover crop (CC), 2) termination timing of the cover crop (TT), and 3) herbicide programs (HP). This study assessed how these factors influence waterhemp density and cash crop yield. The trial is being conducted at the Western Agricultural Research Station, in South Charleston, Ohio, with a fully factorial randomized complete block design (RCBD) that includes 16 treatments and 4 replications. Factor levels consist of: 1) absence or presence of a CC (67 kg seed ha^{-1}), 2) early or late TT, and 3) HP of PRE-only, PRE+POST simple, PRE+POST comprehensive, and no-herbicide. The experiment is implemented within a corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.] crop rotation system. Initial data of waterhemp density and germinable seed bank were collected prior to the establishment of the experiment, and crop and weed measurements were taken at multiple points during the 2024 growing season to evaluate treatment effects. Data were analyzed using the GLIMMIX procedure in SAS 9.4. For waterhemp density, neither CC nor TT had any influence at any evaluation timing. HP had an effect on waterhemp density, wherein there were no differences between the PRE-only, PRE+POST simple, and PRE+POST comprehensive, however, the no-herbicide treatment was higher than these other treatments 21 days after the PRE application. The same trend was observed for the waterhemp density counts 28 days after POST application and harvest. First-year results showed that the presence of CC reduced corn yield to an average of 9668 kg ha^{-1}, compared to 11733 kg ha^{-1} without CC. TT did not influence yield. Among HP treatments, no yield differences were found between the PRE-only, PRE+POST simple, and PRE+POST comprehensive programs, however, the no-herbicide treatment was lower relative to these other treatments. The relatively low waterhemp density observed in this season may be attributed to drought conditions, which could have limited the germination and establishment. This experiment will continue in the upcoming growing season with soybean to further assess treatment impacts and to provide more information on integrated pest management strategies for waterhemp control in corn-soybean rotation systems in Ohio.

Integrating Intra-Row Electrocution and Glyphosate Manages Glyphosate-Resistant Kochia (*Bassia scoparia*) (120)

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Kochia is a highly competitive summer annual that can cause severe yield losses. Because glyphosate-resistance has compromised kochia control in soybean, integrated weed management approaches are needed to minimize yield losses. A greenhouse study was conducted to evaluate a small-scale electrocution device, used alone and in combination with glyphosate (Gly), to control inter-row glyphosate-resistant kochia in soybean. The electrocution device consisted of a mobile platform mounted with a negative terminal to ground electrical current into the soil, a positive terminal to pass current into weed plants via contact, and a glass cover to protect crop plants. An initial experiment determined the optimal device travel speed and voltage for controlling glyphosate-resistant and glyphosate-susceptible kochia. Twenty kochia seedlings were grown with potting soil in 25.4 × 50.8 cm trays in two rows planted on either side of a central Gly-resistant soybean (AG009X8) row. When kochia were 5-8 cm tall, four electrocution treatments were applied: 18kV at 20 or 40 seconds per tray and 9kV at 20 or 40 second per tray. A second experiment evaluated seven treatments: 18kV, 9kV, Gly+18kV, Gly+9kV, Gly alone, weedy check, and weed-free check. The travel speed of the electrocution device was 40 seconds tray^{-1}. Glyphosate was applied at 1680 g ae ha^{-1} with AMS at 2.5% v/v. Kochia plants were electrocuted at 5-10 cm tall for the first repetition and 13-15 cm tall for the second. Kochia control and soybean injury were determined at 7, 14, and 21 days after treatment (DAT), with dry biomass assessed at 21 DAT. Optimal kochia control was observed three weeks after electrocution, indicating steady plant cell death from electric shock energy. In the first experiment, electrocution treatments showed similar kochia control at 7, 14, and 21 DAT (finally attaining 68-85% control at 21 DAT). Kochia biomass remained consistent across electrocution treatments (5-14 g tray^{-1}). Kochia control was greater with a travel speed of 40 second tray^{-1} compared to 20 second (85% vs. 68-73% kochia control at 21 DAT). For the first repetition of the second experiment, Gly+18kV and Gly+9kV achieved 100% control at 21 DAT, differing from 18kV, 9kV, and glyphosate (87.54%, 81.12%, and 25.51%, respectively). For the second repetition, Gly+18kV and Gly+9kV resulted 96% kochia control at 21 DAT. Kochia biomass at 21 DAT was lower with glyphosate-electrocution combination (0-3 g tray^{-1}) compared to glyphosate alone (31-62 g tray^{-1}) and weedy check (79-102 g tray^{-1}) for both repetitions. Soybean injury was not observed. Maximum soybean biomass was associated with Gly+18kV and Gly+9kV (33-36 g tray^{-1}) compared to the weedy check (10 g tray^{-1}). Overall, glyphosate-electrocution combination maximized inter-row glyphosate-resistant kochia control and protected soybean growth. Increased kochia height may reduce electrocution efficacy, but combining electrocution with herbicides can effectively manage larger weed plants.

Enhancing Weed Control: Tank-Mix Approaches with Metribuzin for Managing *Amaranthus* and Other Weed Species (122)

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Tank-mixing metribuzin with other pre-emergence herbicide is commonly utilized to enhance weed management in crop production. This study examined the broad-spectrum weed control effectiveness of tank-mixing metribuzin with other pre-emergence herbicides across various U.S. sites. The study was designed as a randomized complete block design with 11 treatments, and 4 replicates at 14 participating universities. The treatments include a nontreated control as well as tank-mix partners in combination with a low and high rate of metribuzin. The low metribuzin rate at each location was selected based on a rate that provided good *Amaranthus* spp. control in a prior titration trial; the high rate was selected by researchers to provide greater residual weed control with little or no soybean injury. Metribuzin rates varied by state; typical low rates were 0.42 kg ai ha^{-1} and high rates were 0.63 kg ai ha^{-1}. Trials were placed on fields with good *Amaranthus* pressure and a broad spectrum of other weeds. Data collected are visual estimates of weed control by various species and soybean injury 14, 28, and 42 days after planting. Additional data include soybean height, yield, weed density, and weed dry biomass. In addition to a nontreated control, the following are the core treatments used with low and high rates of metribuzin: 1) metribuzin alone, 2) metribuzin + cloranslam-methyl + flumixozin, 3) metribuzin + flumioxazin + pyroxasulfone, 4) metribuzin + cloransulam-methyl + flumioxazin + pyroxasulfone, 5) metribuzin + (flumioxazin + pyroxasulfone + metribuzin). Metribuzin treatment effects on total weed biomass were often not different within sites, except for Nebraska and North Dakota, where low rates of metribuzin alone had higher biomass than metribuzin at high rates or with tank mixes. The dry biomass of *Amaranthus* spp. was affected by tank-mix treatments. Metribuzin tank-mixes at low and high rates decreased dry biomass. The highest *Amaranthus* spp. biomass was generally observed in untreated controls, and one or more tank-mixes reduced weed densities across *Amaranthus* and other species. The combination of metribuzin + cloransulam-methyl + flumioxazin + pyroxasulfone consistently achieved the lowest weed densities for *Amaranthus* spp. and common lambsquarters (*Chenopodium album* L.) in Indiana. High metribuzin rates led to reductions in weed densities for velvetleaf (*Abutilon theophrasti* L.) in Wisconsin and common lambsquarters in Indiana. In contrast, other species like *Amaranthus* spp., large crabgrass (*Digitaria sanguinalis* (L.) Scop.), woolly cupgrass (*Eriochloa villosa* (Thunb.) Kunth,), and green foxtail (*Setaria viridis* (L.) P. Beauv.) did not exhibit differences between low and high metribuzin rates. Soybean yields were generally higher in plots treated with herbicide combinations compared to untreated controls.

The metribuzin + flumioxazin + pyroxasulfone tank-mix achieved the highest yield in Nebraska. This research highlights the effectiveness of metribuzin-based tank-mixes for broad-spectrum weed control, with some suggestion that increasing rates may expand the spectrum of weed control.

Exploring Integrated Weed Management Strategies for Soybeans (*Glycine max*) with Different Planting Dates (123)

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Managing pigweeds in soybean is a significant challenge for farmers. Currently, varied row spacing, and herbicide combinations are used to control pigweed, but many farmers are shifting to early soybean planting to optimize farm management. We hypothesized that planting date has a significant effect on weed control and crop yield. To test this hypothesis, experiments were conducted at near Manhattan and Ottawa Kansas in 2022 and 2023, using a split-block design with four replications. The main plots were two planting dates—early (four to seven weeks before the normal date) and late (late May to late June) and subplots included a factorial combination of two row spacings (38 and 76 cm) and six herbicide programs. The herbicide programs included two pre-emergent herbicides: sulfentrazone+metribuzin and flumioxazin+metribuzin with one of two post-emergent herbicides: 2,4-D choline+glyphosate or 2,4-D choline+glyphosate+*S*-metolachlor. Weed-free and non-treated controls were included. Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus*) were the dominant weed species at Manhattan and Ottawa, respectively. Visible weed control, weed biomass, and crop yield were collected. Data were subject to analysis of variance (α=0.05) and means were separated using Tukey's HSD when appropriate. Four to 7 and 8 to 11 weeks after planting (WAP) in Manhattan 2022, Palmer amaranth control by sulfentrazone+metribuzin was less than flumioxazin+metribuzin applied to late-planted soybean. Similarly, in Manhattan 2023, sulfentrazone+metribuzin resulted in lower weed control than flumioxazin+metribuzin at both planting dates 4 to 7 WAP. There were no differences in weed control among treatments 8 to 11 WAP at Manhattan 2023. Waterhemp control at Ottawa 2022 was similar for all treatments 8 to 11 WAP but in 2023, weed control was greater in late-planted compared to early-planted soybean and greater in narrow rows compared to wide rows. At R7 soybean in Manhattan 2022, both herbicides resulted in Palmer amaranth biomass similar to the weed free check regardless of planting date and row spacing. However, in Manhattan 2023 the greatest biomass was from nontreated soybean planted late in wide rows. Similarly, in Ottawa 2022, late-planted nontreated soybean had the greatest waterhemp biomass when pooled across row spacing and when pooled across preemergent herbicide. Weed control and crop yield were similar for all post-emergent treatments. In Manhattan 2022, soybean yield was greater in late-planted compared to early-planted soybean regardless of preemergent herbicide. Conversely, in Ottawa 2022, soybean yield was greater in early-planted soybean regardless of preemergent herbicide. When data were pooled across row spacing, planting soybean early resulted in greater yields than the corresponding pre-emergent herbicide treatments applied to late-planted soybean. In Ottawa 2023, late-planted soybean yielded more than early-planted soybean regardless of row spacing and preemergent herbicides. These results support our hypothesis. Flumioxazin+metribuzin controlled pigweeds better than sulfentrazone+metribuzin, and weed control was greater with narrow than wide rows, regardless of planting date. However, fewer pigweeds were present in early-planted soybean. The influence of planting date on yield was influenced by environmental factors. Thus, it is imperative to consider long-term weather forecasts when possible.

Impact of Soil Residual Herbicide Application Timing on Herbicide Fate and Weed Control in Early-Planted Soybean in Wisconsin (124)

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In the US Upper Midwest, the growing trend of early soybean planting calls for research on how this agronomic practice affects weed management. As farmers move toward earlier soybean planting, the in-season effectiveness of soil residual herbicides applied at planting may decline due to wider window for herbicide dissipation prior to active emergence of target weed species. This study aimed to identify the fate and efficacy of soil residual herbicides applied at different times in early-planted soybeans. Field trials were conducted as a randomized complete block design with four replications at two Wisconsin locations (Arlington, which has silt loam soil with 3.5% OM, and Brooklyn, which has sandy loam soil with 1.6% OM) in 2022 and 2023. Treatments consisted of a 2X5 factorial with two soil management practices (tillage and no-till) and four application times (at planting, 14, 28, and 42 days after planting) of fomesafen / S-metolachlor + imazethapyr plus a non-treated check (no PRE herbicide applied). Soil samples (0-7.6 cm) were collected 21 days after the last treatment time to quantify S-metolachlor and imazethapyr concentration in the soil. The weed community at Arlington included common ragweed (*Ambrosia artemisiifolia* L.), common lambsquarters (*Chenopodium album* L.), and foxtail (*Setaria* spp.) species, representing an easier-to-control weed spectrum. In contrast, waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer], a difficult-to-control species due to its resistance to herbicides and extended emergence window, was the predominant species at Brooklyn. Weeds were counted at the time of the first POST application (2,4-D + glyphosate + acetochlor) for each treatment, which was triggered when either approximately 20% of plants within a specific treatment reached a height of 10 cm or when soybeans reached the R1 growth stage (whichever happened first). Moreover, a late POST (LPOST) application was triggered at R1 growth stage if additional weed emergence was observed. A major difference in precipitation patterns was observed between 2022 and 2023, with much lower precipitation during the 2023 growing season, especially at the Arlington location. Compared to the earliest applications, the Arlington location showed lower dissipation of imazethapyr and S-metolachlor over time. In contrast, Brooklyn exhibited faster dissipation, with later applications containing at least 77% and 61% higher concentrations of imazethapyr and S-metolachlor across years, respectively. At POST time, no major differences were observed in weed density across soil residual application times for both locations. No LPOST was needed at Arlington, whereas at Brooklyn, the first two residual application timings (at planting and 14 days after planting) required a LPOST for waterhemp control in 2022. These results suggest that when planting soybean early and using residual herbicides, in lighter soils like those at Brooklyn, earlier applications can be less effective for waterhemp control due to faster herbicide dissipation. Conversely, in heavier soils like those at Arlington, slower dissipation rates mean growers can potentially spread their spraying workload across the early season while still maintaining effective weed control, provided that residual herbicides are applied and activated before the onset of emergence of target weed species and according to label requirements.

Long-term Effect of Residual Compared to POST Herbicide Programs on the Soil Seedbank of Waterhemp (125)

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In 2022, common waterhemp (*Amaranthus rudis J.D. Sauer*) was ranked as the most common and the second most troublesome weed in the United States and Canada. Its success can be attributed to high seed fecundity and genetic diversity that facilitates rapid evolution of herbicide resistance. A field experiment was established in 2018 to evaluate the long-term influence of various PRE + POST herbicide programs on the soil seedbank of waterhemp in Missouri. Treatments included: an untreated control; a mid POST only application of glyphosate (1.26 kg ae ha^{-1}) and dicamba (0.56 kg ae ha^{-1}); 3 treatments containing a residual PRE with flumioxazin (0.088 kg ai ha^{-1}) or acetochlor (1.26 kg ai ha^{-1}) followed by a POST application of glyphosate with either glufosinate (.656 kg ai ha^{-1}) or dicamba; and 2 treatments of a residual PRE using acetochlor and metribuzin (0.51 kg ai ha^{-1}) with a POST application of an overlapping residual of acetochlor plus fomesafen (1.52 kg ai ha^{-1}) or acetochlor. All treatments with a residual PRE also included a late POST application of glufosinate. Waterhemp stand counts were taken immediately before the initial and late POST applications and seed counts were obtained from soil samples collected every year around harvest. Treatments that included a residual PRE and a late POST had significantly lower seed numbers (both total seeds and viable seeds) in the soil compared to the untreated and the POST only treatments. These treatments also had a significantly lower percentage of the original viable seed population, ranging from 13-30% of the original population whereas the untreated and POST only treatments contained 77 and 68%, respectively. Throughout the years, waterhemp density was reduced by all treatments at the initial and late POST application timings. The herbicide programs effectively controlled the waterhemp while the untreated and single pass POST treatments caused a shift to higher densities of annual grasses. Long-term management of waterhemp must take an herbicide program approach and focus on reducing seedbanks in the soil.

What Does Weed Management in Early Planted Dry Beans Look Like? (126)

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Dry beans are a short-season crop, maturing within roughly 100 days, which creates unique weed management challenges. This shortened growing window provides growers opportunities to plant later and harvest earlier than typical corn and soybean systems. Traditionally, dry beans in Michigan have been planted in the first week of June, but recent studies suggest potential agronomic benefits to earlier planting dates in other crops. Consequently, there is growing interest among Michigan's dry bean producers in exploring earlier planting. The objective of this research was to compare weed management systems and yield in early- and ultra-early planted black beans 'Zenith' with normal planted black beans. A field experiment was established in 2024 at two locations: Michigan State University Agronomy Farm (MSU; East Lansing, MI) and Saginaw Valley Research and Extension Center (SVREC; Frankenmuth, MI). The experiment was set up as a split-plot randomized complete block design with planting date (3 times) as the main plot factor and weed control programs for the sub-plot factor. The three planting dates included: "ultra-early" (targeting the 1st week of May), "early" (3rd week of May) and "normal" (1st week of June). Weed management systems included: (1) PPI pendimethalin (1,060 g ha^{-1}) + dimethenamid-P (578 g ha^{-1}) at crop planting alone, (2) followed by (fb.) POST imazamox (35 g ha^{-1}) + bentazon (733 g ha^{-1}), (3) fb. POST imazamox + bentazon + dimethenamid-P (526 g ha^{-1}), (4) fb. POST imazamox + bentazon + dimethenamid-P fb. late postemergence (LPOST) fomesafen (280 g ha^{-1}) 5 d after POST. Additional treatments include treatments 2-4 followed by preharvest desiccation (PREHARV) of saflufenacil (25 g ha^{-1}) + paraquat (840 g ha^{-1}) prior to harvest and a non-treated control. Weed control was evaluated 7 and 21 days after treatment (DAT) after POST, and weed counts were recorded 21 DAT. Dry bean stands were counted and harvested for yield. A 15% reduction in dry bean stands was observed for the non-treated control across all planting dates at MSU but remained consistent at SVREC across all treatments and planting dates. PPI and PPI + POST treatments reduced weed counts by >75 and >93% at MSU, respectively, and by >98% at SVREC for the PPI alone treatment. At MSU, the highest yielding treatment across all three planting dates was PPI fb. POST imazamox + bentazon + dimethenamid-P. All other treatments provided similar yields except for PPI alone and non-treated control, exhibiting >24 and >50% reductions, respectively. Averaged across all weed management strategies, black beans planted at the normal time outyielded the early and ultra-early planting times by 11 and 28%, respectively. Additional research is needed to further understand the impact of dry bean planting dates on weed control and yield.

Exploring Short Statured Corn Management Strategies for Weed Control in Michigan (127)

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Corn (*Zea mays*) represents one of the most economically important crops worldwide. Weed competition can reduce yield by 50%. Short statured corn may allow for easier management throughout the season, the ability to withstand deleterious weather, and increased populations. However, implications on weed control are unknown. Therefore, the objective of this study is to evaluate weed management programs, leaf architecture, and plant population on short vs. tall statured corn performance. The study was conducted at two locations: East Lansing and Morrice, MI; and followed a completely randomized block design with four replications. Factorial combinations consisted of three corn hybrids, tall, short (upright leaves), and short (pendulum leaves); two planting population, 79,000 ha^{-1} and 99,000 ha^{-1}, and three herbicide programs, preemergence (PRE), early postemergence (EPOS), and two-pass (POST). The following measurements were taken throughout the season: weed control, crop injury, leaf orientation, leaf angle, and canopy cover. Weed biomass and yield were collected at the end of the season. All data except canopy cover 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. Annual grass control in East Lansing was modified by two-way interaction of hybrid by population and main effect of herbicide (p=0.0001, p=0.0165). Annual grass control in the tall-low population was 3.5, 3.2, and 3.2% less than in the pendulum-high, upright-high, and pendulum-low averaged across herbicide treatments. PRE herbicide treatment reduced annual grass weed control by 6.4 and 3.2% compared to the POST and EPOS, averaged across hybrid and population. There was no difference in annual grass control at Morrice. Corn ear height in East Lansing was modified by a three-way interaction between herbicide, population, and hybrid (p=0.0001). Ear height in the tall-low-EPOS was 10.6% lower than tall-low-POST, 9% lower than the tall-low-PRE, and 4.7 % lower than tall-low-no herbicide treatment. Ear height in the pendulum-high-POST was 9.8, 7, and 0.8% lower than pendulum-high-EPOS, pendulum-high-no herbicide treatment, and pendulum-high-PRE. Corn ear height in Morrice was modified by a three-way interaction between herbicide, population, and hybrid (p=0.0029). Ear height in the tall-low-EPOS was 11.3% lower than tall-low-PRE and 11.1% lower than tall-low-POST. Common lambsquarters (*Chenopodium album*) count in East Lansing was modified by the main effect of herbicide (p=.0001). However, there was no difference amongst herbicide programs except for the no herbicide treatment. Rate of canopy closure was not different amongst any treatment in either location (p>0.1). Yield in East Lansing was modified by the two-way interaction between hybrid and population and a main effect of herbicide (p=0.0001, p=0.0001). Yield in the pendulum-low was 17.4, 15.5, 12.1, and 9.2% lower than the tall-low, upright-high, pendulum-high, and upright-low averaged across herbicide treatments. Yield in the no herbicide treatment was 21.6, 21, and 17.2% lower than the PRE, POST, and EPOS averaged across hybrid and population. In conclusion, results from year one of this study suggest weed management for short-statured corn hybrids are similar to traditional tall hybrids. This study will be repeated next year.

The Impact of Spray Coverage on Weed Control When Using Novel Targeted Herbicide Application Technologies (128)

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New emerging agricultural technologies such as smart sprayers are progressively making their way into the global agricultural market. These innovative sprayers come equipped with cameras that enable real-time weed detection and with high-speed computer units responsible for processing images and activating the necessary nozzles. Different sprayer manufacturers may adopt different approaches concerning the activation of nozzles upon weed detection by the camera system. Additionally, various nozzle types are being discussed and recommended for these systems. The objectives of this research were to investigate the role of nozzle type, number of nozzles triggered upon weed detection, and boom height on spray deposition and weed control. The weed control

study was conducted in 2023 and 2024 at two Wisconsin locations, Arlington (ARL) and Janesville (ROK). A complementary study to investigate spray coverage was conducted at ARL over two years. The studies were conducted as 2x2x2 factorial experiment, including additional weedy checks for the weed control study. A three-nozzle boom (CO2 pressurized and calibrated to deliver 140 l/ha with nozzles positioned 38 cm apart) mounted on a bicycle wheel was built to conduct this research. Two different nozzle types with similar droplet size classification were selected: flat fan nozzle (TeeJet DG 80015) and even flat fan nozzle (TeeJet TP40015E). Nozzles were evaluated at two different boom heights: 53 cm from the target, which represents the ideal field scenario for the selected nozzle spacing, versus 76 cm from the target simulating boom sway. Lastly, the efficacy of one versus three nozzles activation was compared. Treatments received glufosinate POST (656 g ai ha^{-1} as the target rate) and application occurred when soybeans were at V4 growth stage and weeds were ~10 cm in height. Biomass samples were collected 14 days after treatment (DAT). *Ambrosia artemisiifolia* was the target weed at ARL and *A. trifida* at ROK. Three sub-samples were obtained from the middle row where simulated target weeds were present. According to our results, the activation of three nozzles, regardless of their type or height, provided better spray coverage (36-44%) and more effective weed control (>95%) across treatments within the target area. When only one flat fan nozzle was activated at the ideal target height (53 cm) it provided 89% control in the target area and 22% spray coverage whereas the higher boom treatment resulted in lower weed control (76%) and lower spray coverage (12%). Similarly, when a single even fan nozzle was activated at ideal target height (53 cm) it provided 92% control in the target area and 32% spray coverage, but the higher boom treatment resulted in lower weed control of 86% and 27% spray coverage. For single nozzle activation, the even fan nozzle provided better weed control and spray coverage than the flat fan nozzle. Activation of multiple nozzles upon weed detection may be necessary to achieve adequate spray coverage and effective weed control with smart sprayers, regardless of nozzle type or boom height.

Herbicide Programs for Weed Management in Early-Planted Soybean (129)

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In Indiana, the traditional planting window to for soybean is between late April and mid-May. However, more producers are choosing to plant soybean before corn in early April due to greater tolerance to cold soils and the potential for increased yield from a longer growing season. Since several soil residual herbicides have application restrictions limiting the application window prior to soybean emergence, selection and timing of preemergence (PRE) herbicides to coincide with the initial period of spring emergence for problematic weeds such as waterhemp can be challenging. During early spring cold temperatures can increase soybean sensitivity to PRE herbicides, resulting in reduced soybean stand and canopy formation. This negative impact can lead to increased weed pressure due to reduced canopy coverage, stand failure, and insufficient herbicide availability in the soil during peak weed emergence. Experiments were conducted at three locations in Indiana in 2024 to evaluate the effect of four planting dates (early, early-mid, mid-late, and late) and three herbicide programs (full rate soil residual herbicide followed by

POST, reduced rate soil residual herbicide followed by POST, and POST only) on soybean stand, weed control, and soybean yield. Soil residual herbicides were applied on the soybean planting date, with POST application occurring when weeds were 10 to 16 cm tall. Data from each site were analyzed separately and subjected to ANOVA using the "aov" function in R software. For *Chenopodium album*, *Ambrosia trifida*, and *Echinochloa crus-galli*, there was no significant interaction between planting date and herbicide program on weed density at POST. However, these weed species exhibited greater density at the POST application in the early planting compared to the late planting date. The full residual rate program in the early planting date resulted in higher *Amaranthus tuberculatus* density at POST (14 plants m^{-2}) compared to the full residual rate in early-mid, mid-late, and late planting dates (4, 3, and 3 plants m^{-2}, respectively). Canopy coverage was similar for early (46%) and early-mid (44%) planting dates when the early planting date reached R2 growth stage, but greater than the mid-late (33%) and late planting dates (21%). The POST only program had greater canopy coverage (43%) than the full (33%) and reduced (32%) residual rate programs, likely due to crop stunting caused by PRE herbicide application. Soybean stand was affected only by planting date, resulting in reductions of 14%, 9%, and 34% in early planting compared to late planting in the northwest, west-central, and southeast regions, respectively. In the northwest and west-central locations, early planting resulted in 14% and 37% increased yield compared to late planting. However, in early planting greater weed density was observed at the POST application compared to late planting dates, leading to increased selection pressure for herbicide-resistant weeds to commonly used soybean POST herbicides.

Influence of Crop and Weed Canopies on Postemergence Spray Solution Deposition (130)

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Effective herbicide spray coverage is essential for post-emergence (POST) weed management, as inadequate coverage can reduce weed control efficacy, promote herbicide resistance, and ultimately impact crop yields. This two-year study (2023 and 2024) in Wisconsin evaluated herbicide spray deposition within soybean and weed canopies, targeting giant ragweed (*Ambrosia trifida* L.) in Janesville and waterhemp (*Amaranthus tuberculatus* Moq. Sauer) in Brooklyn (4 site-years). A POST application of glufosinate at 656 g ai ha^{-1}, combined with AMS (1428 g ha^{-1}), COC (1% v/v), and pyroxasulfone (91 g ai ha^{-1}), was sprayed at a carrier volume of 140 L ha^{-1} onto 10–15 cm tall weeds and V2-V4 growth stage soybean, depending on site-year. The study compared three nozzles with different droplet sizes: XR110015 (fine), AIXR110015 (coarse), and TTI110015 (extremely coarse), using water-sensitive spray cards (5 × 7.6 cm) to assess herbicide spray deposition. Cards were placed across 9.1 × 3 m plots at five positions within the canopy. Placements at (i) soybean canopy base and (ii) weed canopy base representing “spray interception” scenarios simulating small weeds growing under the crop and taller weeds, while placements at (iii) row middle, (iv) soybean canopy top, and (v) weed canopy top representing “no spray interception” scenarios. Immediately after herbicide application, water-sensitive cards were carefully collected in zip-lock plastic bags and stored in containers away from sunlight to preserve spray patterns. Each card was photographed, and the photographs were then processed with

GOTAS software to estimate the percentage of spray coverage. Spray deposition data were analyzed using ANOVA to assess the effects of nozzle type and placement on herbicide spray coverage whereas replications nested within site-years were treated as random effects. Weed control, measured as biomass reduction relative to non-treated control, and soybean yield (kg ha^{-1}) were analyzed by site-year. Results showed a significant interaction between nozzle type and placement ($P<0.05$). XR110015 provided the highest coverage (33%) in no spray interception but a 78% reduction in coverage due to interception. Compared to XR110015, AIXR110015 had lower no-interception coverage (23%) and a 68% reduction under interception, while TTI110015, with the lowest coverage (19%), experienced a 64% reduction in interception scenarios. No differences in biomass reduction for waterhemp in Brooklyn or giant ragweed in Janesville was detected across nozzle types, though biomass reduction varied by year ($P<0.05$). In Brooklyn, waterhemp biomass reduction was 87% in 2023 and 95% in 2024. In Janesville, giant ragweed biomass reduction was 98% in 2023 and 99.3% in 2024. Soybean yields did not differ across nozzle treatments but varied between years ($P<0.05$), with yields in Brooklyn at 3,416 kg ha^{-1} in 2023 and 4,452 kg ha^{-1} in 2024, and 2,246 kg ha^{-1} in 2023 and 3,544 kg ha^{-1} in 2024 in Janesville. Nozzles with fine droplet spectrum may have greater spray solution interception by the crop and taller weeds compared to the nozzles with coarser droplet size. The AIXR110015 nozzle presented a good balance between spray coverage and crop-weed canopy penetration.

Variable Soil Residual Herbicide Application Rates Should be Determined by More than Just Soil Type (131)

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Applications of soil residual herbicides are performed uniformly across fields that are not spatially uniform for soil type and may require rate adjustments according to product label rate recommendations. These uniform applications in fields with high levels of soil variability could result in decreased weed control for under-application and increased risk of crop injury from over-application. Several factors contribute to different rate recommendations for soil residual herbicides, driven primarily by sorption of these compounds to the soil fraction. Precision application sprayers with individual nozzle control and two boom configurations will facilitate the potential adoption of variable rate application of soil residual herbicides to meet manufacturers recommendations while ensuring best management practices for herbicide resistance. Therefore, the objective of this research was to determine the influence of soil residual herbicide rate, soil type, and seedbank abundance on weed emergence and crop injury. Fields trials were established in 2023 and 2024 on two commercial Indiana fields with high soil variability previously mapped using electrical conductivity data and confirmatory soil sampling. Herbicide rates were determined following the label recommendations for the soil types and a three-tier rate structure (low, medium, high) was developed for sulfentrazone and cloransulam in soybean, and a two-tier structure (low, high) for clopyralid and flumetsulam in corn. Plots were established in a randomized complete block design with all herbicide rates applied on all three major soil types on the fields. In both site years the dominant species were giant ragweed (*Ambrosia trifida*), prickly sida (*Sida spinosa*), and annual grasses on Field A; burcucumber (*Sicyos angulatus*), eastern black nightshade (*Solanum ptychanthum*), and annual grasses were dominant in Field B. Results were highly variable on both fields with individual species emergence prior to POST application being more closely related to soil type than herbicide rate. On Field A the fine <3% OM soil type had the greatest weed emergence compared to the fine >3% OM and medium <3% OM soil type ($F_{3, 33.35} = 3.51$, $P = 0.025$). Burcucumber emergence was higher in the fine >3% OM soil type in both years on Field B ($F_{3, 37} = 11.57$, $P = 1.7e\text{-}05$). Overall, this research indicates that rate determination for variable rate applications of soil residual herbicides may need to consider both soil weed seedbank abundance and soil type for developing field prescriptions.

Oral 3 – Student Contest - Horticulture and Specialty Crops; Range, Pasture and Vegetation Management; Weed Biology and Ecology

Field Surveys of Lima Bean Reveal Shortcomings in Weed Management (132)

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To understand the scope of weed interference in commercial lima bean (*Phaseolus lunatus* L.) production, lima bean fields were surveyed for weeds that escaped control near the time of crop harvest from 2019 to 2022 in two major U.S. production regions. Overall weed abundance was determined based on relative density, frequency, and uniformity throughout surveyed fields. Approximately 52 weed species were observed, with differences in weed communities between the Mid-Atlantic and Midwest regions. Significant weeds in the Mid-Atlantic region included common chickweed, (*Stellaria media* (L.) Vill), amaranth species (*Amaranthus* spp.), and morningglory species (*Ipomoea* spp.). Significant weeds in the Midwest region were foxtail species (*Setaria* spp.), common lambsquarters (*Chenopodium album* L.), and amaranth species. Crop management practices used in the fields were obtained from collaborating farmers and vegetable processors. Widely adopted mechanical weed control methods included preplant tillage and interrow cultivation. Common herbicides included preemergent *S*-metolachlor and halosulfuron-methyl. Bentazon was the most common postemergent herbicide. A classification and regression tree model was used to determine linkages among weed coverage from surveys and management factors. Despite adoption of multiple chemical and mechanical weed control methods, this survey revealed extensive weed problems in many production fields. Greater diversification of integrated weed management systems is needed, especially for amaranth species. This survey will help guide future research efforts for weed control in lima bean production.

Does Flumioxin Application Timing and Rate Influence Non-russet Type Potatoes? (133)

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Many weather-related factors, including high wind, splashing or heavy rain or cool temperatures at or near potato emergence, may result in potato injury when fields were treated with flumioxazin (Chateau EZ). Previous research has shown that with ‘Russet Burbank’ showed that when at least 2.5 inches of rain occurred within 10 days of an herbicide application, the greatest total and marketable yields resulted when flumioxazin 1X was applied two days after planting without hilling followed by metribuzin/metolachlor ½X after regular hilling. However, it is unclear if chipping or red cultivars under irrigated conditions would respond similarly. Treatments included the labeled rate of flumioxazin applied early followed by the half rate of metribuzin/metolachlor after regular hilling, labeled rate of flumioxazin applied after regular hilling, and the labelled rate of metribuzin/metolachlor after regular hilling. The chipping cultivars included Dakota Pearl, Snowden, and Waneta. The red cultivars included Red Norland, Red LaSoda, and Sangre. Weed control was excellent the entire season and injury was less than 5%. For the chippers there was a significant cultivar by treatment interaction for all tuber grades, marketable and total yield which was caused by ‘Waneta’ as the other two cultivars responded similarly to all treatments. ‘Waneta’ may have sensitivity to metribuzin/metolachlor, which was exacerbated by the early application of flumioxazin, as plots receiving just flumioxazin had the highest yields in each category followed by metribuzin/metolachlor alone, and the least yield in each category when flumioxazin was applied early followed by metribuzin/metolachlor after regular hilling. For the reds there was a significant cultivar by treatment interaction for most grades, marketable and total yield which was caused by ‘Sangre’ and ‘Red LaSoda’. The highest ‘Sangre’ marketable and > 10 oz. tuber grade occurred when plots were sprayed with flumioxazin at regular hilling, while the lowest was when plots were sprayed with flumioxazin applied early followed by the half rate of metribuzin/metolachlor after regular hilling. The highest ‘Red LaSoda’ total, marketable, > 10 oz., and 6-10 oz tuber grade occurred when plots were sprayed with flumioxazin at regular hilling, while the lowest was when plots were sprayed with flumioxazin applied early followed by the half rate of metribuzin/metolachlor after regular hilling. ‘Red Norland’ responded similarly to all treatments. Results suggest that ‘Waneta’ and ‘Red LaSoda’ may have sensitivity to metribuzin/metolachlor, which was exacerbated by the early application of flumioxazin.

Utility of Cover Crops and Residual Herbicides for Early Season Weed Control in Sweetpotato (*Ipomoea batatas* L.) (134)

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Weed management options in sweetpotatoes (*Ipomoea batatas* L.) are confined to mechanical practices and a limited number of herbicides. Early season weed control is critical, as formation of tuberous roots is primarily determined shortly after transplanting slips. Therefore, this research aimed to minimize weed pressure in sweetpotatoes by integrating cover crops and/or preemergence (PRE) herbicides. Cereal rye (*Secale cereale* L.) or winter wheat (*Triticum aestivum* L.) were drill seeded in the fall in 3 x 6 m plots. Cover crops were terminated in the following spring with glyphosate or tillage prior to “Beauregard” sweetpotato slip transplanting. Other treatments included flumioxazin applied as a PRE, and/or S-metolachlor applied as an overlapping residual herbicide. Besides an untreated control, season-long hand weeding was also included for comparison. A total of eight treatments were arranged in a RCBD with 4 replications in a two-year field experiment. Weed biomass data collected across both years were square root transformed prior to ANOVA, and significant means were separated based on Fisher’s Protected LSD ($P \leq 0.05$). At 4 weeks after transplanting, all treatments reduced weed biomass up to 95 and 100% for grass and broadleaf weeds, respectively, compared to the untreated control. By 8 weeks after transplanting, the use of cover crops significantly reduced total weed biomass up to 88% compared to the untreated control, regardless of herbicide program. Without cover crop, herbicide application to tilled ground reduced total weed biomass up to 45%, regardless of herbicide program. However, early season weed suppression was not influenced by cover crop selection. Similarly, no additional early season weed control effect was found when S-metolachlor was applied to flumioxazin-treated plots. However, follow up S-metolachlor application significantly improved total storage root yield in Year 1 by approximately 2-fold, compared to plots that received flumioxazin alone. No statistical difference in yield was found between cover crop plots and tillage plots with both herbicides. Although hand weeded plots resulted in season-long weed control and comparable tuber yields, this practice is time and labor intensive. These findings suggest that the use of cover crops offers effective early season weed control, which is reflected in reduced weed establishment, regardless of herbicide program. For farmers who choose not to use cover crops, application of overlapped preemergence herbicides to tilled ground could provide a similar effect by reducing early season weed competition and improving root yield due to extended residual effects. The Year 2 root yield is currently being determined and will be discussed in the presentation.

Asian Copperleaf: An Obscure Find in Iowa Crops (135)

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Asian copperleaf (*Acalypha australis*) is native to China and adventive in numerous other regions of the world. In 2016, it was found for the first time in a Northeast Iowa seed corn field. ISU’s herbarium curator used a Canadian Euphorbiaceae expert to identify the specimen. At that time the expert reported the only known North American infestation of Asian copperleaf was in New York City. Iowa Department of Agriculture and Land Stewardship worked with the seed company managing the infested field but were unable to locate the source of infestation. While little is known about the North American populations, some populations in Asia are known to have herbicide resistances to herbicides used in row crop production, like glyphosate and fomesafen. Since 2016, Asian copperleaf has been discovered in corn and soybean fields in eight Iowa counties. Most infestations have been detected at harvest since the species has a prolonged

emergence pattern and typically remains underneath the crop canopy throughout the growing season.

Utilizing Silage Tarps, S-metolachlor, and Hand Weeding for Weed Management in Onions (136)

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In the U.S., small farms play a crucial role in food security and agricultural diversity. Small-scale onion (*Allium cepa* L.) production faces unique challenges due to the crop's susceptibility to weed competition. Consequently, early-season weed management is critical to maximize onion yield. To address this concern, field trials were conducted at the Purdue Student Farm in West Lafayette, IN in 2023 and 2024 to investigate the effectiveness of silage tarps (opaque plastic sheets), *S*-metolachlor, and hand-weeding for weed management in small-scale onion. The experiment design was a split-plot, with the main plot factor of tarping (tarped or non-tarped) and subplot factor of *S*-metolachlor application (once or twice) with or without hand-weeding. Tarping was performed for five weeks immediately after soil preparation, and tarps were removed immediately before transplanting 'Hamilton' onions. *S*-metolachlor (1,064 g ai ha^{-1}) was applied at 2 weeks after transplanting (WATr) or at 2 and 4 WATr. Hand-weeding was conducted at 7, 8, and 9 WATr. Data collection included weed count, weed control [0% (no weed control) to 100% (complete weed control)], above ground weed biomass, and onion yield. Tarped beds had significantly reduced early-season broadleaf weed density (10 per plot) just after lifting the tarp compared to non-tarped beds (36 per plot). Tarping also reduced end-of-season aboveground weed biomass, with non-tarped plots averaging 510 g per plot compared to 350 g per plot in tarped plots. However, when hand-weeding was implemented, it proved to be more effective in further reducing weed biomass, enhancing onion yields, and achieving superior overall weed control throughout the season, regardless of whether tarps were applied or not. *S*-metolachlor enhanced weed control with at least one application, however, no additional benefits were observed with a second application when hand-weeding was also utilized. At 8 WATr, treatments with one *S*-metolachlor application plus hand-weeding averaged 85% weed control, while those with two applications plus hand-weeding, averaged 86%. This suggests that while *S*-metolachlor can be effective, its optimal use may be in combination with hand-weeding. Additionally, no significant differences in above ground weed biomass or onion yield were observed with two applications of *S*-metolachlor. Treatments that received one *S*-metolachlor application plus hand-weeding had 72 g per plot of above ground weed biomass, and treatments with two *S*-metolachlor applications plus hand-weeding had 51 g per plot. Treatments with one *S*-metolachlor application combined with hand-weeding produced 20.52 kg of onions per plot, compared to 20.66 kg per plot for those receiving two *S*-metolachlor applications along with hand-weeding. Tarping effectively minimized early-season weed flushes and, when combined with other practices like herbicides and hand-weeding, can lead to optimal weed suppression throughout the growing season and maximized onion yield. However, our results

showed that hand-weeding had a greater impact on weed control and onion yield compared to tarping and *S*-metolachlor. Overall, this study contributes to the limited research on weed management practices in small-scale onion production, providing valuable insights to help farmers make informed decisions regarding the adoption of tarping, herbicides and hand-weeding.

Yellow Foxtail [*Setaria pumila* (Poir.)] Reduces Establishment of Alfalfa Interseeded into Corn (137)

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Interseeding alfalfa (*Medicago sativa* L.) into corn (*Zea Mays* L.) is a novel approach that increases the production of high-quality forage and reduces the risk of nutrient and soil loss from cropland. Annual grass weeds like yellow foxtail [*Setaria pumila* (Poir.)] can reduce the success of alfalfa establishment and are difficult to manage in the interseeding system. This study evaluated ground cover, fall biomass, and fall plant density of interseeded alfalfa in response to varying populations of *S. pumila*. Our goal was to identify a threshold for initiating control of annual grasses to ensure good establishment of alfalfa in this intercropping system. Groundcover of interseeded alfalfa growing under corn declined as foxtail density increased from 0 to 125 plants m^{-2} in July, August and October with the sharpest decline in August (upto a 70% reduction in alfalfa cover). This reduction in groundcover was associated with a decline in post-establishment shoot and root mass and a reduction in alfalfa plant density from 246 to 146 plants m^{-2} in October. Results suggest that June *S. pumila* populations should be kept < 50 plants m^{-2} to obtain recommended fall alfalfa densities of 200 plants m^{-2} that are needed to maximize alfalfa yield the following year. This research provides crucial information to practitioners on when annual grass management is needed to ensure successful alfalfa establishment in this interseeded system.

Evaluating the Carryover of Corn Residual Herbicides Containing Clopyralid on Alfalfa Establishment and Productivity (138)

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Alfalfa (*Medicago sativa* L.) is an important perennial legume in Wisconsin that is grown in rotation with corn. It provides high-quality forage to dairy producers and other ecosystem services (e.g. reduced pests, improved soil health, reduced soil erosion). Alfalfa establishment failure has been reported in fields where clopyralid was previously applied. To address this concern, we evaluated clopyralid alone and mixed with other active ingredients found in two herbicides commonly used for weed control in corn within Wisconsin (Resicore, SureStart II). Treatments included clopyralid applied alone (61, 68, 140, and 280 g a.e. ha^{-1}) Resicore, (984 g a.i. ha $^{-1}$ acetochlor, 105 g a.i. ha^{-1} + mesotrione + 66 g a.e. ha^{-1} clopyralid) and Surestart II (790 g a.i. ha^{-1} acetochlor + 164 g a.e. ha^{-1} clopyralid + 25 g a.i. ha^{-1} flumetsulam). We also included all

combinations of all active ingredients for Resicore and SureStart II in the experiment to evaluate if combinations of active ingredients changed the injury observed. This resulted in seventeen herbicide treatments that were applied at two locations, Arlington and Lancaster, Wisconsin. Herbicides were applied POST on 06/09/2023 to no-till corn fields. Corn silage was harvested in early September and soil was collected in November in each plot (10cm deep) at each location for use in a greenhouse bioassay. Alfalfa was planted in April 2024 to evaluate the impact of treatments on its establishment and productivity under field conditions. In both greenhouse and field studies, alfalfa above and belowground biomass was collected, dried and evaluated via analysis of variance and means were separated with LSD at $p<0.05$ if differences were detected. Differences were observed between locations in the greenhouse bioassay. At Lancaster, reductions in aboveground biomass were observed with eleven treatments, of which clopyralid was present in nine. Belowground biomass was reduced from three treatments, all of which contained clopyralid. No other active ingredients alone or combined displayed a consistent reduction in alfalfa biomass. Arlington did not show any reductions in above or belowground biomass. Despite observed differences in the greenhouse bioassay, no differences in stand establishment or productivity were observed in field trials at either location. Results suggest herbicide concentrations in the soil in November were capable of injuring alfalfa, but these levels degraded to non-injurious concentrations by spring of 2024. The reasons for different responses between locations are not clear. Soil type (silt loam), percent organic matter (3%), and precipitation were similar at both locations. Lancaster had high levels of soil-borne pathogens that infected alfalfa roots and impacted growth, whereas Arlington did not. This suggests soil-borne diseases impact sensitivity to herbicide carryover. Further research is needed to quantify this interaction.

Weed Management Challenges Associated with Railroad IVM sites (139)

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Effective management of vegetation along railroad tracks is required under federal law to ensure public safety and prevent dry plant material from fueling fires. Industrial vegetation management (IVM) in this habitat is challenging for several reasons. First, the railroad ballast and accompanying right-of-way (ROW) is comprised of native soil mixed with medium to coarse gravel. As a result, herbicide adsorption and extended residual activity in this porous environment is challenging. Second, the railroad ROW traverses across diverse geographies and is adjacent to many agronomic and specialty crops. Applications of herbicides in ROW must be precisely made to preclude damage to sensitive vegetation. Third, evolved herbicide-resistant species from agronomic cropping areas spread onto the railroad ROW, limiting the effectiveness of some postemergence herbicide options. Fourth, in the absence of any "crop" canopy, weed management in the railroad ROW extends over a majority of the growing season. Across the Midwest, the primary problematic weed species include waterhemp (*Amaranthus tuberculatus* Moq. [J.D.Sauer]), common lambsquarters (*Chenopodium album* L.), ragweed species (*Ambrosia* spp.), annual grasses, and kochia (*Brassia scoparia* L.). Because trains are a primary mechanism for shipping grain, kochia is emerging as a significant problem on the railroad ROW into the eastern US. This presentation will discuss traditional and current practices for managing weeds in IVM areas such as the railroad ROW.

Fall Herbicide Applications in Early and Late Planted Winter Wheat (14)

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Fall postemergence herbicide applications for weed control in winter wheat are gaining interest among Michigan farmers. Adverse fall weather conditions and delayed previous crop harvest can extend winter wheat planting 4 to 6 wks from the ideal planting date of mid-September. Currently, the impact of fall herbicide applications on early- versus late-planted winter wheat remains largely unexplored. Therefore, a field experiment was established in the fall of 2022 and 2023 in East Lansing (MSU) and in 2023 in Frankenmuth (SVREC), Michigan. This experiment was established as a split-plot randomized complete block design with four replications with the main plot factor as herbicide application date 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 wks later. There were two fall herbicide application timings for the early-planted wheat at Feekes stage 1.3 and then approximately two wks 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. Additional treatments of pyrasulfotole + bromoxynil alone and tank-mixed with mesosulfuron were also applied to the early and late planted wheat in the spring at Feekes stage 5. Wheat injury was not apparent from the fall herbicide applications at SVREC. However, fall herbicide applications to early-planted wheat that contained mesosulfuron and pyroxsulam resulted in 7-18% injury at MSU in both years, 14 d after treatment (DAT). The injury consisted of yellowing and stunting. Injury from these early fall applications were not apparent in the spring. In 2024 at MSU, the late-fall applications to late-planted wheat of mesosulfuron and pyroxsulam resulted in stunting in early-April, but wheat was able to outgrow this by late-April. Weed numbers were low at SVREC. However, at MSU weed dynamics were influenced by planting date; early-planted wheat resulted in 4.5- and 0.6-times more weed biomass than late-planted wheat in late-May 2023 and 2024, respectively. Mid-season weed biomass was lowest from early fall herbicide applications compared with the later application timing for early planted wheat. Weed biomass for the fall application in late-planted wheat was similar to the early fall application in early planted wheat at both MSU locations. Earlier fall applications of pyrasulfotole + bromoxynil tank-mixed with mesosulfuron or pyrasulfotole provided good control of all weeds, including annual bluegrass (*Poa annua*). Fall applications of pyrasulfotole + bromoxynil alone or with mesosulfuron on early-planted wheat showed greater winter annual weed control than spring applications. In 2 out of 3 site-years, early planted wheat outyielded late-planted wheat by 807-1278 kg ha^{-1}. Overall, fall herbicide applications, particularly for early planted wheat, may be the most effective strategy for weed control, as spring weather can complicate herbicide application timing. Additionally, earlier wheat planting facilitates quicker canopy closure, helping suppress summer annuals and optimize winter wheat yields.

Wild Parsnip (*Pastinaca sativa*) Control in Forb Rich Prairies with Florpyrauxifen-methyl (141)

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Wild parsnip (*Pastinaca sativa* L.) is an invasive monocarpic perennial commonly found throughout the midwestern United States. While its sap can cause burns to human skin, it also impacts natural and managed habitats by competing with desirable vegetation. Forb dominant prairies are of concern as wild parsnip invades and may displace native forbs. While wild parsnip is effectively managed by several herbicides (e.g., 2,4-D, metsulfuron), these products injure/kill desirable forbs, making them an option only if applied to individual plants. Florpyrauxifen-benzyl is a new herbicide that many native forbs have tolerance to, thus it could be broadcasted, but its effectiveness on wild parsnip is not known. To investigate this, studies evaluated the effect of florpyrauxifen-benzyl on wild parsnip in native forb-rich prairies. Randomized complete block studies were conducted over two years to evaluate if 0.9-29.4 g ai ha^{-1} of florpyrauxifen-benzyl broadcasted controls wild parsnip when applied in spring when rosettes and seedlings are present. Florpyrauxifen-benzyl effectively controlled wild parsnip with 90-100% reductions in parsnip density with all rates tested 60 days after treatment. To assess the benefit in an invaded forb rich prairie, applications of of florpyrauxifen-benzyl (14.7 g ai ha^{-1}) alone or florpyrauxifen-benzyl (11 g ai ha^{-1}) mixed with imazapic (35 g ae ha^{-1}) were compared to a non-treated control. Both treatments reduced wild parsnip density 60 days after treatment. Control persisted one year after treatment with an >85% reduction in parsnip plants from both treatments. Total forb cover was reduced one year after treatment by 24% with florpyrauxifen-methyl alone but the reduced rate mixed with impazapic did not differ from the non-treated control. Sensitivity of forbs to treatments varied with some not impacted (*Rudbeckia hirta*, *Silphium perfoliatum*, *Monarda fistulosa*), and others severely impacted (*Zizia aurea, Ratibida pinnata*) by treatments. Results suggest that florpyrauxifen is effective at controlling wild parsnip at low rates and many, but not all forbs are tolerant to applications at these reduced rates.

Control of Glyphosate-resistant Waterhemp (*Amaranthus tuberculatus*) in Truvera Sugarbeet (142)

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Control of glyphosate-resistant (GR) waterhemp (*Amaranthus tuberculatus*) in glyphosate-resistant sugarbeet is a challenge for Michigan growers. 'Truvera' is a new herbicide-resistant trait package in sugarbeet that confers resistance to glyphosate, glufosinate, and dicamba. Implementing these additional herbicide sites of action into current weed management strategies will help growers improve waterhemp control. A field experiment was conducted in grower's fields with GR waterhemp in 2023 and 2024 in central Michigan. The experiment consisted of 18 different herbicide programs including a non-treated control. Herbicide programs included treatments requiring the 'Truvera' trait and current grower standards in GR sugarbeet. Herbicide programs were grouped by three different application strategies based on sugarbeet growth stage: PRE followed by (fb.) 2 fb. 6-8 leaf sugarbeet (8 total treatments); 2 fb. 6-8 fb. 12 leaf sugarbeet (4 total treatments), and 2 fb. 6-8 leaf sugarbeet (5 total treatments). PRE herbicides consisted of dicamba or a reduced rate of *S*-metolachlor (0.53 kg ha^{-1}). Dicamba, glyphosate, glufosinate, and various combinations of these products were applied alone and in combination with acetochlor at the 2 and 6-8 leaf applications. The 12-leaf application only included glyphosate. Standard treatments included 3 applications of glyphosate at 2 fb. 6-8 fb. 12-leaf sugarbeet, and an overlapping residual strategy including *S*-metolachlor (PRE) fb. glyphosate + acetochlor (2-leaf) fb. glyphosate + acetochlor (6-8 leaf). Each herbicide treatment was kept within the maximum use limit for each product. Significant sugarbeet injury was only apparent in 2024. The combination of glufosinate and acetochlor applied to 2 leaf sugarbeet resulted in 15% injury, 7 d after treatment (DAT). Injury symptoms consisted of abnormal leaf shapes and stunting. Sugarbeet injury from this treatment was less than 5% by 14 DAT. Waterhemp control 20 d after planting was 86 and 70% from dicamba and *S*-metolachlor, respectively. At the end of the season, 10 of the 17 herbicide programs examined provided similar control (88% or greater) to the programs with the highest control (98%). Highest control was in treatments that included dicamba PRE fb. glufosinate + acetochlor (2-leaf) fb. glufosinate alone or with acetochlor (6-8 leaf). Other programs that provided good control included either dicamba or *S*-metolachlor PRE fb. glufosinate POST (2 or 6-8 leaf timing); or dicamba or glufosinate (2-leaf) fb. glufosinate (6-8 leaf) with at least one of these applications including acetochlor. Glufosinate applied twice POST did not provide sufficient waterhemp control (60%) and the current standard of overlapping residual herbicides only provided 40% waterhemp control. End of season waterhemp biomass was reduced by at least 85% in treatments that provided good waterhemp control (88% or greater) compared with the overlapping residual standard treatment. Overall, the ability to include glufosinate and dicamba in sugarbeet weed control programs when combined with residual herbicides in 'Truvera' sugarbeet provides growers with much needed options for control of GR waterhemp. Future research is needed to examine how 'Truvera' sugarbeets may be implemented in reduced tillage and different row width systems to further improve weed control.

Characterization of Resistance to Protoporphyrinogen Oxidase Inhibitors PRE and POST in a Waterhemp (*Amaranthus tuberculatus*) Accession from Wisconsin (143)

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Herbicide resistance in waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] has been confirmed to auxin mimics, ALS-, PSII-, EPSPS-, and PPO-inhibitors POST in WI. Following a report in WI of a suspected PPO-inhibitor resistant waterhemp population (A92) not controlled with sulfentrazone PRE, our objective was to characterize the response of the A92 accession to PPO-inhibitor herbicides PRE and POST. Dose-response greenhouse experiments were conducted to quantify the sensitivity of the A92 and A66 (susceptible) accessions to flumioxazin (1x: 105 g ai ha^{-1}), fomesafen (1x: 263 g ai ha^{-1}), and sulfentrazone (1x: 280 g ai ha^{-1}) PRE. For A92, herbicide rates ranged from 0.015x to 8x the labeled rate. For A66, herbicide rates ranged from 0.015x to 1x the labeled rate. Herbicide non-treated controls (NTC) were included in each experiment. At 28 DAT, emerged plants per experimental unit were counted. Data were converted into percent plant count compared to the NTC. Dose-response greenhouse experiments were conducted to quantify the sensitivity of the A92 and A82 (susceptible) accessions to fomesafen [1x: 263 g ai ha^{-1} + 0.5 v/v % high surfactant oil concentrate (HSOC) + 1,430 g ha^{-1} ammonium sulfate (AMS)] and lactofen (1x: 219 g ai ha^{-1} + 0.4 v/v % HSOC + 2,804 g ha^{-1} AMS) POST. Herbicide rates ranged from 0.015x to 16x the labeled rate. At 21 DAT, aboveground biomass was harvested. Data were converted into percent biomass compared to the NTC. The A92 accession was resistant to fomesafen PRE [A92 ED_{50}: 39.8 (±10.3) g ai ha^{-1} vs. A66 ED_{50}: 12.9 (±3.5) g ai ha^{-1}], and to sulfentrazone PRE [A92 ED_{50}: 92.5 (±17.3) g ai ha^{-1} vs. A66 ED_{50}: 30.0 (±7.2) g ai ha^{-1}]. The flumioxazin PRE ED_{50} for A92 and A66 accessions did not differ [A92 ED_{50}: 4.0 (±1.4) g ai ha^{-1} vs. A66 ED_{50}: 0.7 (±0.6) g ai ha^{-1}]. The A92 accession was resistant to lactofen POST [A92 ED_{50}: 63.3 (±7.8) g ai ha^{-1} vs. A82 ED_{50}: 3.4 (±0.8) g ai ha^{-1}] and to fomesafen POST [A92 ED_{50}: 54.0 (±8.3) g ai ha^{-1} vs. A82 ED_{50}: 9.2 (±1.1) g ai ha^{-1}]. In conclusion, our results showed that the A92 accession is resistant to fomesafen (3.1-fold) and sulfentrazone (3.1-fold) PRE compared to the A66 accession, and resistant to lactofen (18.6-fold) and fomesafen (5.9-fold) POST compared to the A82 accession, being the first confirmed case of a waterhemp accession resistant to PPO-inhibitors both PRE and POST in WI. The molecular mechanism conferring PPO-inhibitor resistance in A92 is being investigated. Integrated pest management, including the diversification and mixtures of different herbicide SOAs, is fundamental to mitigate the over-reliance on herbicides and for the long-term sustainability of weed management.

Kochia (*Bassia scoparia*) and Common Ragweed (*Ambrosia artemisiifolia*) Control with Phenmedipham in Sugarbeet (144)

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Glyphosate-resistant (GR) weeds including kochia (*Bassia scoparia* L.) and common ragweed (*Ambrosia artemisiifolia* L.) pose significant challenges for sugarbeet (*Beta vulgaris*) growers in Minnesota and North Dakota. To address this, greenhouse and field experiments were conducted to evaluate phenmedipham efficacy for controlling GR kochia and GR common ragweed. A phenmedipham (Spin-Aid®) 24(c) local needs label was approved in 2023 and 2024 in Minnesota and North Dakota and supports its use alone or in tank-mixtures for postemergence (POST) kochia, common ragweed and common lambsquarters control in sugarbeet. Experiment objectives were to optimize phenmedipham rate, tank-mixture partner with phenmedipham, and application number to improved weed control in sugarbeet production. Herbicide treatments were applied with a CO_2-pressurized (207 kPa) bicycle wheel sprayer calibrated to 159 L ha^{-1}, using shielded 8002XR nozzles spaced 51 cm apart to minimize drift. Treatments involved one-time, two-time, or three-time phenmedipham application spaced five to seven days apart, targeting kochia and common ragweed growth stages. Kochia and common ragweed control assessments were visible, comparing the treated plot to adjacent non-treated areas. Sugarbeet injury was greatest 14 to 21 days after treatment and increased with the number of phenmedipham applications, especially under temperatures exceeding 24°C or when tank-mixed with *S*-metolachlor. Injury symptoms were transient, with reduced phytotoxicity 21 days after final application. In the greenhouse, sequential phenmedipham applications (182, 273, and 363 g ai ha^{-1}) mixed with ethofumesate and methylated seed oil provided improved control of kochia compared to single applications. Likewise, two-times phenmedipham applications with ethofumesate, glyphosate, and methylated seed oil significantly improved common ragweed control compared to single phenmedipham applications with ethofumesate alone. Field results were similar to greenhouse outcomes with enhanced kochia and common ragweed control with multiple times phenmedipham applications. Multiple applications reduced root yield but did not affect sucrose content or recoverable sucrose per hectare. These results highlight the potential of repeat phenmedipham applications for managing GR kochia and common ragweed in sugarbeet. Future research will investigate phenmedipham rate based on environmental conditions, tank-mixtures, and explore efficacy from a four-times application.

Kochia, Russian Thistle, and Palmer Amaranth Field and Basic Research in Colorado (145)

Philip Westra*
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No abstract submitted.

Oral 4 – *Symposium* – Local Perspectives of Weed Management Challenges and Solutions

Farmer Panel Discussion. Local Perspectives of Weed Management Challenges and Solutions (146)

Sarah Lancaster, Dan Bigham*, Scott Gigstad*, Mike Guetterman*, Ed Hesse*

FARMER FORUM: FARMER-FOCUSED CONVERSATIONS TO IMPROVE WEED MANAGEMENT RESEARCH AND EXTENSION. Communication between farmers and scientists is necessary for the development of actionable weed management research. Constructive conversations between the two groups can be prevented because of work schedules and workload demands, differences in communication styles, and other constraints. The goal of this symposium is to create an open space for farmers to share their perspectives and answer questions from scientists. The symposium will feature a diverse panel of row-crop farmers from eastern Kansas and western Missouri who were invited to discuss their experiences pertaining to weed management. Topics discussed will include: current weed management challenges and strategies, the future of weed management, effective communication strategies, and more. Come to this symposium for a lively conversation about how your research can best serve our farmers and how their questions, concerns, and ideas can become your next project.

Oral 5 – Row Crop Herbicide Management

Effect of Dicamba-Based Preemergence Herbicide Tank Mixtures on Weed Control in Soybean (147)

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The uncertainty surrounding dicamba use in the United States, due to its off-target movement to sensitive plants and a recent court ruling prohibiting its use in dicamba-resistant soybean, has raised serious concerns among farmers, who now have limited herbicide options to manage problematic weeds. Preemergence (PRE) application of dicamba with other soil residual herbicides may help minimize off-target movement and preserve dicamba's use. Field experiments were conducted in 2022 and 2023 in Minnesota and North Dakota, and in 2021 and 2022 in Wisconsin, to evaluate the effectiveness of dicamba-based PRE herbicide mixtures in soybean. Dicamba, tank mixed with other residual herbicides enhanced weed control across all sites. In Minnesota, dicamba-based herbicide tank mixes provided an average waterhemp [*Amaranthus tuberculatus* (Moq) J.D. Sauer] control of 72%, compared to 59% for treatments without dicamba. Similarly, waterhemp control in North Dakota improved from 74% with residual herbicides alone to 97% when tank mixed with dicamba. In Wisconsin, dicamba-based tank mixes resulted in 96% control of common ragweed (*Ambrosia artemisiifolia* L.) and 83% of velvetleaf (*Abutilon theophrasti* Medik.), versus 83% and 73% for those species, respectively, without dicamba. For common lambsquarters (*Chenopodium album* L.), giant ragweed (*Ambrosia trifida* L.), and kochia [*Bassia scoparia* (L.) A. J. Scott], PRE dicamba application with residual herbicides improved average control by 17, 20, and 23%, respectively, compared to residual herbicides alone. The results from this research outlined the effectiveness of PRE application of dicamba with other residual herbicides for effective weed management in the Upper Midwest.

Development of Convintro™ Brand Herbicides for Managing *Amaranthus* Species in Corn and Soybean: Field Performance Update (148)

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The continued development and spread of herbicide resistance constitutes a major threat to corn and soybean producers. Weeds such as some Amaranthus species 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 a herbicide technology that features diflufenican, an active ingredient that is a new site of action for control of Amaranthus spp. in corn and soybean production systems in North America, 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.

Intrava™ MX Is a New Herbicide Featuring Amicarbazone for Weed Control in US Field Corn (149)

Ryan Henry*[1], Ryan Bryant-Schlobohm[2], Cody Gray[3], Carlos Antonio Koury d'Arce Junior[4]
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Intrava™ MX is a combination of amicarbazone and mesotrione and is pending registration with the US EPA. This herbicide can control many broadleaf weeds and provide suppression of annual grass weeds in corn. Intrava™ MX is intended for use in the pre-plant/at-plant application timing and can serve as a foundation for a two-pass weed control program. The SC formulation is loaded at 480 grams active ingredient per liter, which will provide the end user with convenient use rates and mixing flexibility. Intrava™ MX is centered around the active ingredient amicarbazone, which is a new active ingredient for the US corn grower.

Effect of Multiple Very-long-chain Fatty Acid-inhibiting Herbicide Applications on Soybean Yield (150)

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Very-long-chain fatty acid-inhibiting herbicides (Group 15) are applied extensively to manage weeds preemergence. Group 15 herbicides are being applied post residual to reduce the amount of later germinating weeds. Minimal data is present to determine the influence of multiple applications of these herbicides on soybean yield. Field studies were conducted to determine the effect of multiple applications of Group 15 herbicides on soybean yield. Experiments were conducted at two locations in North Carolina (Kinston and Rocky Mount) and South Dakota (South Shore and Volga), respectively. *S*-metolachlor (1703 g ai ha^{-1}) and encapsulated acetochlor (1261 g ai ha^{-1}) were applied at three different timings: preemergence, early postemergence (V2-V3), and mid postemergence (V5-V6). All timings were applied in a factorial arrangement. These two herbicides were selected based on immediate plant availability (*S*-metolachlor) and delay availability (encapsulated acetochlor). Glufosinate (655 g ai ha^{-1}) and glyphosate (1260 g ae ha^{-1}) were applied between the early and mid postemergence application to manage weeds that could confound putative yield loss. Experiment location was considered random to increase the inference of the data. The main factor herbicide did not influence soybean yield. The main factor of timing influenced soybean yield where a loss occurred with the early and mid postemergence application. The interaction between herbicide and timing was not significant. These results suggest that multiple applications of Group 15 herbicides do not affect soybean yield.

Introducing INTERLINE® MEGA Powered by L-tek™ for Optimized L-glufosinate Applications to Glufosinate-Tolerant Row and Specialty Crops (151)

Ryan Bryant-Schlobohm*[1], Ryan Henry[2], Cody Gray[3], Carlos Antonio Koury d'Arce Junior[4]
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Glufosinate is a reliable tool for the integrated management of key weed species in glufosinate-tolerant soybean, corn, canola, cotton, and other crops. Glufosinate is a racemic mixture of D- and L-enantiomers, where the herbicidal activity is isolated to the L-enantiomer. Through formulation innovation, the D-enantiomer has been removed, offering a purified formulation of L-glufosinate. Upon EPA registration, UPL will provide L-glufosinate under the brand name INTERLINE MEGA, for use in glufosinate-tolerant soybean, corn, canola, cotton and other traditional glufosinate use sites. Replicated field trials have been conducted across the United States in all relevant crops. Results document comparable performance and crop safety profiles of L-glufosinate when compared to traditional glufosinate. This efficacy is achieved with a 45% reduction in field use rate, while maintaining the standard agronomics associated with glufosinate applications.

Surtain Herbicide: Introduction of New Residual Premix for Corn Market (152)

Sanjeev Bangarwa*[1], Kevin Hartman[2], Nicholas Steppig[3], Matthew Osterholt[4], Josh Putman[1], Troy Klingaman[3], John Frihauf[2], Brent McCaskey[4], Scott Fitterer[5], David Carruth[5], Douglas Findley
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Surtain™ herbicide is a novel formulation that will be commercially introduced by BASF Corporation in 2025 offering a broad-spectrum residual premix with PRE and POST flexibility in corn. Surtain™ herbicide is a premix of saflufenacil (capsulated) and pyroxasulfone and is labelled for use in field corn grown for grain, seed, or silage. 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. Furthermore, Surtain™ herbicide will offer flexibility to corn growers expanding the application window. 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. Besides these benefits, Surtain™ herbicide will be a relatively low use rate herbicide (9.2 to 17 fl. oz/A depending on soil texture) with enhanced liquid fertilize compatibility. Surtain™ herbicide obtained Federal and State registrations earlier this year and will is expected to be launched by BASF Corporation to the corn market for use in the 2025 season.

Surtain Herbicide: Field Performance and Success Stories (153)

Josh Putman*, Sanjeev Bangarwa
BASF Corporation, Research Triangle Park, NC

Surtain™ herbicide stands alone as “the new kid on the block”. With its innovative solid encapsulation technology only available through BASF Corporation, Surtain™ herbicide offers a unique one-two punch of residual endurance for tough-to-control weeds and creates flexibility for retailers and growers to make timely applications as well as options to tank-mix the best products for their operation in accordance with label directions. Over the past decade, more than 450 university and biology research trials have been conducted to produce a superior and crop-safe herbicide premix containing PPO-inhibiting chemistry. This product has demonstrated performance on problematic weeds, especially the ever-evolving herbicide-resistant *Amaranthus* spp. The unique premix of encapsulated saflufenacil (group 14) and pyroxasulfone (group 15) provides long-lasting residual weed control along with a wider application window (pre-plant through V3 stage of corn) making it an important pest management tool for years to come. Surtain™ herbicide serves as the foundational layer to season-long weed management programs and has demonstrated outstanding performance across the United States.

Oral 6 – Student Video Contest and Graduate Student Workshop

Critical Timing for Cereal Rye Termination After Corn Planting for Weed Management and Yield (154)

Vipin Kumar*, Amit Jhala
University of Nebraska-Lincoln, Lincoln, NE

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. 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 (11,675 lb ac $^{-1}$) and termination at planting yielding the lowest (5,898 lb ac^{-1}). Across herbicide treatments, termination at planting and at emergence resulted in 93% Palmer amaranth (*Amaranthus palmeri* L.) 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 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 an 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.

From Field Imagery to Data: The Use of Canopeo for Green Cover Measurements (155)

Nikola Arsenijevic*, Rodrigo Werle
University of Wisconsin-Madison, Madison, WI

Green cover estimation is a vital part of assessing vegetation health and development. Traditional methods, such as visual estimation of crop injury and growth can include a certain level of bias during data collection, driving the need for more accurate and objective data acquisition using digital tools as estimators. This video highlights the use of Canopeo, developed by combined efforts of the Division of Agricultural Sciences and Natural Resources, the App Center, and the Soil Physics research group at Oklahoma State University. Canopeo is a mobile app and a software plugin, for estimating green cover from field imagery that can be useful for weed scientists. Specifically, it showcases how Canopeo processes images captured by a GoPro 8 Hero Black and are analyzed through the MatLab Canopeo Plugin. The primary objective of this video is to provide an overview of the Canopeo platform, demonstrating how to effectively prepare the necessary hardware and software for its use in quantifying green cover during in-field data collection related to crop injury and development. Moreover, the video outlines the steps involved after image acquisition, focusing on pre-processing and processing images using the Canopeo plugin in MatLab. Canopeo utilizes RGB color bands to differentiate green pixels from other colors, calculating the percentage of green cover in relation to the total area. This is represented as a black-and-white ratio, where the white portion indicates the estimated percentage of green cover. This approach reduces the subjectivity and bias of visual estimations, delivering objective data. The decision to implement Canopeo in MatLab was driven by MatLab's powerful data processing capabilities, which allows for the efficient handling of large datasets, making it possible to process hundreds of images quickly. The combination of Canopeo with a GoPro camera and MatLab plugin offers flexibility for fieldwork, enabling researchers to capture plot areas efficiently and analyze the data with precision. Canopeo's application goes beyond just assessing green cover; it is also valuable for tracking crop development over time. For instance, it can help estimate the days required for full canopy closure with images collected over time. In the context of herbicide evaluation and general vegetation monitoring, Canopeo can provide a reliable solution for gathering digital data such as weed coverage in bareground experiments, herbicide injury on crops, and crop development over time. This video demonstrates that Canopeo can be a powerful tool for researchers and agronomists looking to estimate green cover objectively. By integrating GoPro imagery and the MatLab Canopeo Plugin, this workflow offers an optimal, reliable method for field data collection and analyses. Whether for research on crop development, herbicide programs, or broader vegetation monitoring, Canopeo can yield valuable objective measurements.

Comparison of UAV and Airplane for the Application of Fungicide in Corn (156)

Jesse Yount*, Mandy Bish, Rusty Lee, Wayne Flannery, Trace Thompson, Mattheus Noguera, Grant Coe, Grady Rogers, Delbert Knerr, Kevin Bradley
University of Missouri, Columbia, MO

Timely fungicide applications in corn (*Zea mays*) production are essential in reducing disease and preserving yield. Fungicide applications in corn are commonly applied by aircraft. However, unmanned aerial vehicles (UAV) may have the potential to provide a more timely option for fungicide application. Current recommendations for fungicide applications are when corn matures to the tasseling or early silk growth stage (VT/R1). However, when disease pressure is high, application recommendations may extend through the milk stage (R3 growth stage) and occasionally the dent stage (R4). An experiment was conducted at three locations across Missouri in 2024 to determine the feasibility of utilizing UAV for the application of fungicides to field corn. Each farmer selected the product and treatments were applied to corn at the R1 or R3 growth stage with the DJI Agras T40 UAV and compared to an industry standard aircraft. Three treatments were evaluated at each location; 1) application of the fungicide with the UAV delivering 19 L ha^{-1}, 2) application of the fungicide with the UAV delivering 37 L ha^{-1}, and 3) application of the fungicide with an aircraft delivering 28 L ha^{-1}. Airplane models varied by location. To evaluate spray coverage, water sensitive spray cards were placed in three locations within each plot on the adaxial and abaxial surfaces of two leaves above the ear leaf, two leaves below the ear leaf, and two ear leaves at the time of application. Disease severity ratings occurred before application and at the R3 and R6 growth stages. When considering application volume, aircraft treatments at one location had significantly less coverage than either UAV treatment. Gray leaf spot (*Cercospora zeae-maydis*) severity was reduced following fungicide applications with the drone compared to the aircraft at one of the three locations. No differences were observed at the other two locations. Similarly, tar spot (*Phyllachora maydis*) severity was reduced following fungicide applications with the drone compared to the aircraft at one of the three locations but no differences were observed at the other two sites. Initial results from this experiment indicate that for fungicide applications to corn, UAV have the potential to provide similar or better spray coverage and disease suppression than aircraft applications.

Tank Mixing Metribuzin to Improve Palmer Amaranth Control (157)

Landon Duff*[1], Salina Raila[1], Lalit Mohan[1], Sarah Lancaster[1], Aaron Hager[2]
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Palmer amaranth is a challenging weed for Kansas soybean farmers, partly because of herbicide resistance. Mixing herbicides from different groups is recommended to control Palmer amaranth and reduce the risk of evolving herbicide resistance. Specifically, there is a growing emphasis on the role of metribuzin applied in combination with other herbicides to manage Palmer amaranth in soybeans. However, questions remain regarding the best way to use metribuzin in tank-mixes for Palmer amaranth control. A field study was conducted near Manhattan, KS to quantify Palmer amaranth control and soybean injury by tank-mixes that included metribuzin. Twenty pre-emergence herbicide treatments were included in the experiment. There were eight treatments containing one herbicide and 12 treatments containing two to three herbicides. Tank-mix treatments had either 0.5 or 0.6 lbs metribuzin per acre. Palmer amaranth control and soybean injury were evaluated 21 and 35 days after application (DAA). Palmer amaranth biomass and density were recorded 35 DAA and soybean yield was collected. Data were subjected to analysis of variance ($\alpha = 0.05$) and means were separated with Tukey's HSD when appropriate. Palmer amaranth control was 95 to 99%, 21 and 35 DAA. Treatments that included 0.5 lbs metribuzin per acre had greater Palmer amaranth control 35 DAA than other treatments. Soybean injury35 DAA was 8% or greater when metribuzin was included in the tank-mix; however, soybean yield was similar for all treatments. Based on this study, we recommend tank-mixing 0.5 lbs metribuzin per acre for Palmer amaranth control.

Graduate Student Workshop – Mastering the Art of Job Applications (158)

Moderators:
Cristiana Bernardi Rankrape, Kaitlin Creager; *Southern Illinois University, Carbondale, IL*
Panelists:
Debalin Sarangi, *University of Minnesota*
Samuel Noe, *Valent USA*
Jose Nunes, *Syngenta*
Lucas Riveiro Maia, *Corteva AgriScience*
Mark Bernards, *USDA-ARS*

No abstract submitted.

Oral 7 – *Symposium* – What's New in Extension Plus (Extension; Cover Crops and IWM; Weed Genetics and Herbicide Physiology)

What's New in Extension: Historical IPM Assessment Survey Results from Minnesota (159)

Lizabeth Stahl*, Ryan Miller, Anthony Hanson, David Nicolai, Angie Peltier, Navjot Singh, Debalin Sarangi
University of Minnesota, St. Paul; MN

Extension educators in Minnesota have been asking farmers attending Private Pesticide Applicator (PAR) workshops about the pest management issues they face and the practices they plan to use or are using in an Integrated Pest Management (IPM) Assessment survey since 2003. Responses were collected by paper until 2008, when Turning Technologies ResponseCards were used. Polling results from online workshops have also been included since 2021. All attendees can participate, and responses are voluntary and anonymous. In addition to providing value as an educational, audience engagement, and evaluation tool, the survey acts as a needs assessment that provides guidance for research and educational efforts. Results show a shift in weed challenges over time. Although the three most troublesome broadleaf weeds identified by survey respondents have consistently been giant ragweed (*Ambrosia trifida* L.), common lambsquarters (*Chenopodium album* L.), and waterhemp (*Amaranthus tuberculatus* Moq.), their rank has shifted over time, with waterhemp, followed by giant ragweed, replacing common lambsquarters as the most troublesome broadleaf weed from 2006 to 2020. Respondents have consistently ranked glyphosate-resistance as being the most prevalent herbicide-resistant weed issue on the land they farm (e.g., 75% of respondents in 2024), while resistance to ALS-inhibiting herbicides continues to be likely under-reported (e.g., 15% of respondents in 2024). Farmers have shifted in what is the most common herbicide-resistant crop technology they plan to use in soybean from glyphosate-only (49% in 2018) to the Enlist system (75% in 2024). While an average of 53% of farmers reported using a POST-only program on at least part of their acres from 2003 to 2009, an average of 78 and 82 % of farmers in corn and soybean, respectively, reported using preplant residual or PRE herbicides on at least some of their acres from 2015 to 2020. The use of non-chemical weed management

practices, such as the planting of a cover crop, have also been tracked over time. Survey results have been compared to herbicide-resistant weed surveys conducted across the state. Results have also supported the development of research into non-chemical weed management strategies such the use of cover crops and harvest weed seed destruction. Results have been used to help inform and guide weed management educational efforts, including through the U of MN Extension Strategic Farming Program (z.umn.edu/strategic-farming) and the Minnesota Crop News Blog (https://blog-crop-news.extension.umn.edu/).

Adding Podcasts as Strategy in the War Against Weeds (160)

Sarah Lancaster*[1], Joseph Ikley[2], Alyssa Essman[3]
[1]Kansas State University, Manhattan, KS, [2]North Dakota State University, Fargo, ND, [3]The Ohio State University, Columbus, OH

Podcasts are growing in popularity as a means of communicating information in an on-demand format. This non-traditional outlet may appeal to clients that are less willing or unable to attend traditional in-person Extension events. However, the platform has not been widely utilized by Extension weed scientists. Limited in-person meetings and attendance due to concerns from the COVID-19 required Extension weed scientists to explore new formats of information transfer. The War Against Weeds podcast was initiated in January of 2021 to increase access to weed management information for agricultural professionals in the North Central Region. The podcast is hosted by Libsyn, which allows downloads from the podcast homepage, Spotify, Apple Podcasts, and other audio streaming platforms. Podcast episodes are recorded using Riverside.fm and edited in Adobe Premier Pro. Now in its eighth season, the podcast has over 52,900 downloads of over 100 episodes. Listeners are primarily from the United States, in addition to Canada, Australia, Brazil, Germany, the United Kingdom, and 80 other countries. In a recent listener survey, all respondents said the War Against Weeds podcast does effectively communicate weed management information and over half of the respondents have changed or are considering changing a weed management practice as a result of listening. Our experiences suggest that podcasting is an effective method for disseminating weed management information to a broad audience of farmers, industry personnel, students, and others.

What's New in Extension: New Technology, New Problems (161)

Thomas Butts*, Marcelo Zimmer, Stephen Meyers, Aaron Patton, William G. Johnson, Bryan Young
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The introduction of novel technologies into the weed science discipline has not only provided new opportunities for research and enhancing management strategies, but has also provided new outlets for the distribution of Extension information. However, this has not arrived without its fair share of challenges as well. Shifts in the desired format of information has appeared to shift from printed materials to online posts or audio/visual materials. These alterations have also accompanied perceived shifts in the mindset of stakeholders for their weed control needs and expectations. Numerous artificially-intelligent chatbots have become publicly-available, but their accuracy and consistency remain to be proven. With many of these new tools, other problems have surfaced such as rural connectivity issues, computer processing power, and the technological savviness of prospective users. Continued efforts are needed to integrate these tools into our Extension outreach activities; however, complementary research needs to be conducted to validate many of these tools for accuracy. Furthermore, finding a balance for stakeholders between older and newer distribution methods will be critical to maintain Extension's impact on a diverse clientele-base. This presentation will involve the discussion of observations and current approaches from multiple weed scientists across varying specialties in Indiana when handling these technological outreach transformations.

What's New in Extension? South Dakota (162)

Eric Jones*
South Dakota State University, Brookings, SD

University extension is critical to address stakeholders' needs for weed management. Currently there are no records of how stakeholders manage weeds in row crops or pasture/rangeland in South Dakota. Weed management surveys have been distributed to stakeholders to understand current practices and needs to effectively address weed management in row crops and pasture/rangeland. More responses were recorded for the pasture/rangeland survey (23% completion) compared with the row crop survey (7% completion). Both surveys suggest that weed management is top priority. Herbicides are the primary management tactic but each respondent uses at least three tactics on average. Respondents were mostly satisfied with current management tactics but small percentages of unsatisfied are of concern as well. Cost, effectiveness, current practices and labor were barriers of adopting new tactics. The results of these surveys are currently being used to educate stakeholders to further improve and adapt current weed management plans for each system.

What's new in Extension? Wisconsin WiscWeeds Update (163)

Rodrigo Werle*
University of Wisconsin–Madison, Madison, WI

The Wisconsin Cropping Systems Weed Science Research and Extension Lab (WiscWeeds) at the University of Wisconsin-Madison, established in 2018, focuses on advancing weed management strategies in Wisconsin's corn, soybean, and small grain systems. The program addresses critical challenges, including herbicide resistance monitoring, chemical program efficacy, and the integration of cereal rye as a cover crop for enhanced weed suppression. In recent years, the lab has expanded to include cutting-edge approaches such as targeted herbicide application technologies (e.g., Smart Sprayer) and the use of unmanned aerial vehicles (UAVs) for herbicide application and data collection. This presentation will highlight key research findings from WiscWeeds' ongoing studies and discuss Extension recommendations shared with stakeholders, underscoring the program's commitment to sustainable and innovative weed management solutions.

What's New in Extension in Iowa? (164)

Wesley Everman*
Iowa State University, Ames, IA

No abstract submitted.

Navigating Weed Control Challenges in Kentucky: Observations and Insights from 2024 (165)

Travis Legleiter*
University of Kentucky, Princeton, KY

Johnsongrass (*Sorghum halepense* (L.) Pers.) and Italian ryegrass (*Lolium perenne L. ssp. multiflorum* (Lam.) Husnot*)* have been historical problematic weeds in Kentucky grain crops. An increasing presence, or at least perceived increase, of both species has been observed in Kentucky in the past couple of years. The University of Kentucky Extension Weed Science Program has increased its efforts to further understand control of these two problematic weeds across grain crop systems due to their increasing presence and potential increase in herbicide resistance. The University of Kentucky has observed an increase in herbicide resistant ryegrass in Kentucky with multiple confirmations of glyphosate, pinoxaden, and fenoxaprop resistance. The increasing spread of pinoxaden and fenoxaprop resistant ryegrass has led to increased investigation, promotion, and implementation of the use of soil residual herbicides in Kentucky no-tillage wheat. This movement has included the recommendation and approval of several 24(c) labels for pyroxasulfone based herbicides for use in wheat in Kentucky. The University of Kentucky Weed Science program has also increased its research and extension efforts focused on control of ryegrass prior to no-till corn and soybean planting. Cases of failed ryegrass burndowns that have led to the need to replant no-till corn fields have increased in Kentucky along with multiple confirmations of glyphosate resistance. The University of Kentucky has increased its efforts to understand glyphosate use rates, tank mixes, and application timing for successful ryegrass burndowns in the spring in Kentucky. The program has also increased its research in the use of fall burndowns and residuals for the suppression of ryegrass prior to corn and soybean planting the following spring, including the recommendation and approval of several 24(c) labels for this use.

Johnsongrass was observed to have an increased presence in corn and soybean fields during the spring and summer of the 2024 growing season. This increased presence is likely due to the favorable weather conditions, including a warm winter and early spring. These favorable conditions in combination with early burndowns across Kentucky no-till acres led to a flush and rapid advancement of rhizome Johnsongrass in many fields leading to a perception of increased presence of the weed. Fortunately for Kentucky growers, at planting or late spring burndowns in combination with postemergence herbicide applications were successful in controlling the Johnsongrass flushes. The University of Kentucky increased extension efforts in 2024 to increase awareness of the biology of Johnsongrass and encouraged efforts to decrease the establishment of Johnsongrass rhizomes in Kentucky no-till fields.

The University of Kentucky Weed Science program estimates that Italian ryegrass and Johnsongrass will continue to be problematic weed species across all no-tillage crops in the state. Efforts to increase research and extension efforts focusing on these problematic grasses are ongoing.

What's New in the Peace Garden State? (166)

Joseph Ikley*
North Dakota State University, Fargo, ND

No abstract submitted.

Exploring the Regulation of Sex Differentiation and Floral Development in *Amaranthus palmeri* and *Amaranthus tuberculatus* through Integrated microRNA and Transcriptome Profiling (167)

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University of Illinois Urbana-Champaign, Urbana, IL

Amaranthus palmeri and *Amaranthus tuberculatus* are considered driver agronomic weeds throughout much of the United States due to their ability to evolve resistance to multiple herbicide sites of action. This adaptability is influenced by their dioecious reproductive systems, where separate sexes promote genetic diversity through outcrossing, ultimately enhancing their evolutionary potential. Understanding the fundamental reproductive biology of these species at a genetic level could provide insights into alternative control strategies, yet the genetic mechanisms underlying dioecy remain unclear. Previous transcriptomic studies in *A. palmeri* and *A. tuberculatus* identified genes with sex-biased expression profiles, several of which belong to transcription factor families known to be regulated by short non-coding micro(mi)RNA (18-24 bp). Numerous miRNA families are already known to play key roles in the post-transcriptional regulation of genes involved in many aspects of floral development and differentiation. Therefore, the objective of this research was to identify key miRNAs involved in regulating sex differentiation and floral development in *A. palmeri* and *A. tuberculatus*. Male and female plants of each species were grown under controlled growth chamber conditions for approximately six weeks, after which tissue samples were collected from three tissue types: developing flowers (<1 cm from spike apex), mature flowers (3-5 cm from spike apex), and leaf tissue. Total RNA was isolated from samples of four male and four female plants from each species, and separate miRNA and mRNA libraries were prepared and sequenced on the Illumina NovaSeq X Plus platform. Consistent with previous

findings in *A. palmeri*, differential gene expression analysis of the mRNA dataset indicated that reproductive tissues displayed greater sex-based differentiation than somatic leaf tissues, with mature floral tissue showing the highest degree of differentiation. Identification of miRNAs conserved across taxa and those unique to these species, as well as the analysis of miRNA differential expression patterns is currently in progress. By integrating the miRNA and mRNA datasets, we aim to better understand the genetic regulation of sex differentiation and floral development in these species.

RNAi Based Silencing of PDS Gene in Multiple Plant Species (168)

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RNA interference (RNAi) is an innovative approach for weed management. This study investigated two RNAi approaches i.e. spray-induced gene silencing (SIGS) and virus-induced gene silencing (VIGS) for systemic silencing of the phytoene desaturase (*PDS*) gene in *Nicotiana benthamiana*, *Solanum lycopersicum*, *Solanum nigrum* and *Amaranthus palmeri*. The *PDS* gene sequences from all these species were cloned into the tobacco rattle virus (TRV2) vector to constitute TRV2-NtPDS, TRV2-LePDS and TRV2-PaPDS. As black nightshade and tomato *PDS* gene sequences showed more than 95 % sequence similarity, *LePDS* was used for VIGS in black nightshade. TRV2 along with TRV1 was agroinfiltrated on leaves using needless syringe method. The control plants were agroinfiltrated only with TRV1. Indirect rub inoculation was also tested using leaf inoculum prepared from TRV2-PaPDS and TRV2-LePDS-infected *N. benthamiana* plants. Additionally, SIGS was employed in *A. palmeri*. The coding regions of *PDS* gene were amplified, sequenced and used to synthesize the double stranded RNAs (dsRNAs). Four fully expanded leaves were applied with 2 µM dsRNA solution. In response to VIGS approach the plants showed bleaching symptoms at 3 weeks after treatment (WAT) only in *S. lycopersicum* and *N. benthamiana* and not in others. VIGS and SIGS produced chlorosis, bleaching and stunted growth only in *A. palmeri* at 4 WAT. The results indicate successful silencing of *PDS* gene in *S. lycopersicum* and *N. benthamiana* via direct VIGS and in *A. palmeri* using indirect VIGS approaches, suggesting that delivery of *PDS* gene through *Agrobacterium* was not successful in *A. palmeri,* while none of the methods worked in *S. nigrum.* These results encourage the possibility of RNAi based gene silencing in plants for weed management.

Delaying Cereal Rye Termination Reduces Weed Density in Corn but Can Also Reduce Yield (169)

Erin Haramoto*[1], Matthew Allen[1], Carlene Chase[2], Parmeshwor Aryal[2], Alison Robertson[3], Rashelle Matthiesen-Anderson[3], John Tooker[4], Matthew Boucher[5], Jared Adam[6]
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Using cover crop residue mulches in no-till systems can reduce and delay weed emergence and slow weed growth, resulting in fewer and smaller weeds targeted by post-emergence herbicides. Small grain cover crops, including cereal rye (*Secale cereale* L.), provide more persistent residues and are often used when weed suppression is a goal. To maximize this service, cereal rye termination may be delayed to increase the amount of residue. However, delayed termination to maximize the residue mulch can result in tradeoffs, potentially increasing corn (*Zea mays* L.) seedling disease and herbivory, as well as interfering with planting. Greater cereal rye biomass can also deplete soil water, limiting yield in dry conditions. We participated in a three-year, multi-location common experiment as part of the Precision Sustainable Agriculture project to study tradeoffs related to cereal rye termination time prior to corn. In Kentucky, cereal rye was sown in October 2020, 2021, and 2022. It was terminated the following spring at three timings: “early” (four to six weeks prior to corn planting), “middle” (two to three weeks before planting), and “planting green” (after planting). A control without cereal rye was also included. Each treatment was replicated five times in a randomized complete block design. Corn was planted in April or May with a split application of nitrogen (planting and V5) and residual herbicides; four rows of each plot did not receive the residual to measure the sole impact of cereal rye termination time on weed density. Prior to a post-emergence application at V5, weeds were identified to species and counted. Weed species were categorized as small-seeded broadleaves, large-seeded broadleaves, annual grasses, and perennials. Corn growth stage was assessed twice in plot areas with the residual herbicide; yield and yield components were measured at harvest. Density of the four weed categories was analyzed with ANOVA. Given significant year by treatment interactions, likely due to variable cereal rye biomass and weather, years were analyzed separately. Cereal rye biomass increased as termination was delayed, ranging from 1600 to 2500 kg ha^{-1} for early, 2600 to 4200 kg ha^{-1} for middle, and 4500 to 6500 kg ha^{-1} for planting green. Small-seeded broadleaf, large-seeded broadleaf, and annual grass density was reduced in planting green relative to early termination in 2021 and 2022, but termination time did not impact density of these categories in 2023. Impacts on perennial weed density were less consistent. Despite contributing to reduced density of multiple weed types, later cover crop termination was often associated with lower corn yield – planting green had 18% and 30% lower yield compared to highest yielding treatments in 2021 and 2022, respectively. Corn development, as measured by the vegetative growth stage and seedling biomass, typically lagged behind in planting green. We observed differing impacts of treatments on soil moisture, depending on weather conditions. Further experimentation can refine management recommendations to capitalize on later cereal rye termination before corn.

Soil Health Implications After 5 Years of Cereal Rye Cover Crop Adoption in Corn-Soybean Systems (170)

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Soil management programs that incorporate no-till (NT) with cereal rye (*Secale cereale L.*) cover crop (CC) in corn (*Zea mays*) and soybean (*Glycine max [L.] Merr.*) cropping systems are gaining popularity as prioritizing agriculture sustainability increases. Erosion prevention, reduction of soil disturbance, and weed suppression are all advantageous aspects of this practice that have been widely documented in the literature. While these practices offer numerous potential soil conservation and weed suppression benefits, potential soil health impacts in grain production systems remain uncertain. Soil health assessments are a good way to evaluate the returns of implementing such practices. A common grower question is how long does it take for soil health benefits to become measurable. This research aimed to quantify soil health parameters of corn and soybean rotational systems after a five-year period. One corn and one soybean experiment, initiating a corn-soybean rotation with cereal rye CC, was established in the fall of 2018 and conducted between 2019 and 2023 at both the Arlington and Lancaster Agricultural Research Stations in southern Wisconsin (4 total sites). The experiment was established as a 2x6 factorial in a randomized complete block design. Treatments included six different soil management practices with and without the presence of a pre-emergence herbicide. Conventional tillage (CT), NT, cereal rye terminated ~2 weeks before planting (CCET), cereal rye terminated at planting (CCPT), cereal rye terminated ~2 weeks after planting (CCLT), and cereal rye forage harvest at planting (CCFH) were evaluated. To quantify soil health across treatments, three types of soil samples were collected from all experimental plots: composite samples (ten soil cores per plot; 0-15 cm depth); bulk density with 5 cm diameter slide hammer (1 sample per plot; 0-5 cm depth); and aggregate stability collected with soil knife (1 sample per plot; 0-5 cm depth). Samples were collected when the corn and soybean experiments reached the V2 growth stage in early summer of 2023 (year 5; after two full corn-soy rotations). Data were pooled across locations and crops (4 sites) to identify major trends across soil management practices. Significant treatment results included percent total carbon (C), soil organic matter (SOM), and aggregate stability of both “micro” and “macro” aggregates. Soil management including cereal rye cover crop, despite termination time, had the highest C (2.02-2.18%), followed by NT (1.96%) and CT (1.75%). SOM was highest in CCLT (3.18%), followed by CCFH (3.04%), and then other treatments (<2.97). Aggregate stability showed stronger “micro” aggregates in NT treatments with or without cereal rye when compared to CT, while “macro” aggregates were greatest in cereal rye treatments, followed by NT, then the least being CT. Five years of continuous fall cereal rye cover crop adoption as a soil management practice resulted in measurable soil health improvements.

Oral 8 – Herbicide Application Technologies - Herbicide Application Technologies; Row Crop Herbicide Management

Control of Volunteer Corn in Corn (171)

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Corn-on-corn production systems are common in southcentral Nebraska which can create issues with volunteer corn management in corn fields. Enlist corn is a new multiple herbicide-resistant trait providing resistance to 2,4-D choline, glyphosate, and the aryloxyphenoxypropionate (FOPs) which is commonly integrated in glufosinate-resistant germplasm. The objectives of this study were to evaluate quizalofop, an ACCase-inhibiting herbicide, for glyphosate/glufosinate-resistant volunteer corn control in Enlist corn. Field experiments were conducted at South Central Agricultural Laboratory near Clay Center, Nebraska. Glyphosate/glufosinate-resistant corn harvested the year prior was cross-planted at 49,000 seeds ha^{-1} to mimic volunteer corn in this study. Seven to ten days later, Enlist corn was planted at 91,000 seeds ha^{-1}. Application timing of aryloxyphenoxypropionates (fluazifop, quizalofop, and fluazifop/fenoxaprop) had no effect on Enlist corn injury or yield and provided 97 to 99% control of glyphosate/glufosinate-resistant volunteer corn at 28 d after treatment (DAT). Orthogonal contrasts comparing early POST (30 cm tall volunteer corn) and late-POST (50 cm tall volunteer corn) applications of aryloxyphenoxypropionates (fluazifop, quizalofop, and fluazifop/fenoxaprop) were not significant for volunteer corn control, Enlist corn injury and yield. Fluazifop, quizalofop, and fluazifop/fenoxaprop resulted in 94 to 99% control of glyphosate/glufosinate-resistant volunteer corn with no associated Enlist corn injury or yield loss; however, quizalofop is the only labeled product as of 2024 for control of volunteer corn in Enlist corn. Field experiments were conducted to evaluate a premix of glufosinate/quizalofop for control of volunteer corn in Enlist corn. The premix provided excellent control of volunteer corn; however, it is not labeled as of 2024 for applying in Enlist corn. Field studies were conducted to evaluate the precision sprayer with dual tank option to evaluate interaction of quizalofop applied with or without 2,4-D choline using a single or dual tank. Volunteer corn control with QPE at 39 g ai ha^{-1} + 2,4-D choline at 1,064 g ae ha^{-1} in a dual tank system (applied through a separate tank) was 60% compared to 35% control when mixing the two herbicides in a single tank at 7 d after application (DAA). Mixing quizalofop at 39 g ai ha^{-1} with 2,4-choline at 1,064 g ae ha^{-1} improved control of volunteer corn to 70% but was 20% lower compared to when applied through a dual tank system 14 DAA, indicating the importance of a dual tank precision sprayer. QPE at both rates (39 and 77 g ai ha^{-1}) had antagonistic interaction with 2,4-D choline when mixed in the same tank at 7 and 14 DAA. At 28 DAA, the antagonistic effect was observed with QPE at 39 g ai ha^{-1} + 2,4-choline at 1,064 g ae ha^{-1} in a tank mix, with 8% lower control than expected. Volunteer corn control was ≥ 92% at 28 DAA across treatments, leading to similar Enlist corn yield without crop injury.

Injury Potential to Early Planted Soybean from Various Soil-Residual Herbicides (172)

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The potential to increase soybean yield from early soybean planting has prompted Illinois farmers to plant soybean earlier than historical norms. However, environmental and pest-related factors can negate potential gains in soybean yield. Weed control is of paramount importance toward allowing a soybean crop to express its genetic yield potential. PRE herbicides are essential components of a soybean weed management program, regardless of planting date. Despite this, the potential for soybean injury from PRE herbicides can be increased in early-planted systems. Cold, wet soils not only can prolong soybean emergence, but extend the duration the soybean seedling is exposed to PRE herbicides. Field experiments were conducted in 2024 at Urbana, Illinois located on an area with historically low weed density. The objective of this research was to examine 13 commercial PRE herbicides and sudden death syndrome (SDS) seed treatment (ILevo) potential for soybean injury and potential effect on yield at two planting dates. PRE herbicides were applied at planting at 1x rates according to label directions for soil type and organic matter content. PRE treatments consisted of S-metolachlor (1,499 g a.i. ha^{-1}; Dual II Magnum), pyroxasulfone (160 g a.i. ha^{-1}) + sulfentrazone (287 g a.i. ha^{-1} Authority Edge), chloransulam-methyl (45 g a.i. ha^{-1}) + sulfentrazone (348 g a.i. ha^{-1}; Authority First), S-metolachlor (1,671 g a.i. ha^{-1}) + metribuzin (557 g a.i. ha^{-1}; Moccasin MTZ), S-metolachlor (1,766 g a.i. ha^{-1}) + metribuzin (420 g a.i. ha^{-1}; Boundary), S-metolachlor (1,766 g a.i. ha^{-1}) + sulfentrazone (196 g a.i. ha^{-1}; Broadaxe), pyroxasulfone (112 g a.i. ha^{-1}) + flumioxazin (88 g a.i. ha^{-1}; Fierce EZ), pyroxasulfone (135 g a.i. ha^{-1}) + flumioxazin (105 g a.i. ha^{-1}) + metribuzin (315 g a.i. ha^{-1}; Kyber), sulfentrazone (206 g a.i. ha^{-1}) + metribuzin (410 g a.i. ha^{-1}; Preview), S-metolachlor (2,042 g a.i. ha^{-1}) + chloransulam-methyl (38 g a.i. ha^{-1}) + metribuzin (378 g a.i. ha^{-1}; Tendovo), pendimethalin (1,118 g a.i. ha^{-1}) + metribuzin (424 g a.i. ha^{-1}; Tripzin), saflufenacil (25 g a.i. ha^{-1}) + pyroxasulfone (120 g a.i. ha^{-1}) + imazethapyr (70 g a.i. ha^{-1}; Zidua Pro), and S-metolachlor (1,216 g a.i. ha^{-1}) + fomesafen (266 g a.i. ha^{-1}; Prefix). Postemergence (POST) treatments were applied when weeds were 10 cm tall and consisted of glufosinate (820 g ai ha^{-1}) plus glyphosate (1,260 g ae ha^{-1}) plus ammonium sulfate. Treatments including ILevo seed treatment resulted in greater injury regardless of planting date or PRE herbicide. Individual PRE herbicides did result in greater crop injury and stand loss; however, soybean yield was not negatively affected. Soybean injury was slightly greater in the conventional planting date, although stand loss from the addition of ILevo seed treatment is likely what resulted in a 336–404 kg ha^{-1} soybean yield reduction for both planting dates.

Weed Height Matters: Evaluating the Impact of Herbicide Mixtures on Waterhemp Control Efficacy (173)

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Waterhemp (*Amaranthus tuberculatus*) is a challenging weed in the United States Midwest corn and soybean production systems, known for its rapid growth, prolific seed production, and resistance to multiple herbicide modes of action. Herbicides like 2,4-D and glufosinate have seen increased usage after commercialization of soybean trait technologies conferring resistance to these herbicides. This study aimed to evaluate the impact of 2,4-D and glufosinate applied alone and in mixtures on waterhemp plants at different heights, hypothesizing that taller plants will exhibit reduced herbicide effectiveness to both single herbicide and the mixtures. A dose-response greenhouse study was conducted using two waterhemp populations, one susceptible (A106) and one resistant to 2,4-D (A101), which were grown to treatment application heights of 2.5, 5, 10, 15, 20, and 25 cm at herbicide treatment. The study was designed as a factorial experiment with four replications, repeated over time (two experimental runs), to assess the effects of different waterhemp heights in conjunction with various herbicide applications. Herbicide treatments were applied at various doses of individual herbicides (2,4-D, glufosinate) at rates of 0.125X, 0.25X, 0.5X, 1X, 1.5X, and 2X, as well as in combination treatments. The combination treatments included 2,4-D rates (0.125X, 0.25X, 0.5X, 1X, 1.5X, and 2X) mixed with a fixed rate of glufosinate (1X, 656g ai/ha) and glufosinate (rates 0.125X, 0.25X, 0.5X, 1X, 1.5X, and 2X) mixed with a fixed 2,4-D (1X, 1065g ai/ha) rate. Data collection included plant mortality and biomass harvested 21 days after herbicide applications, with comparisons made to the nontreated control for each individual height, respectively. Non-linear regression model was used to determine ED_{50} (dose required for 50% of biomass reduction). The estimated herbicide doses required to achieve a 50% biomass reduction (ED_{50}) did not differ across waterhemp sizes of 2.5, 5, and 10 cm for 2,4-D and glufosinate applications alone and in mixtures. As plant height increased from 10 to 25 cm, the ED_{50} for 2,4-D exhibited a significant increase for both populations, increasing from 200 g ai ha^{-1} to 1,065 g ai ha^{-1} for the resistant population and from 200 g ai ha^{-1} to 700 g ai ha^{-1} for the susceptible population. In contrast, the estimated ED_{50} for glufosinate was consistently less than 300 g ai ha^{-1} across both populations and all waterhemp heights. No differences were observed in the estimated ED_{50} values for biomass reduction between glufosinate applied alone and glufosinate mixed with 2,4-D across waterhemp heights for both populations. The combination of glufosinate with 2,4-D enhanced the efficacy of 2,4-D, resulting in a reduced estimated ED_{50} for biomass reduction to below 300 g ae ha^{-1} (mixed of 2,4-D and glufosinate) for both populations. These findings support the hypothesis that taller waterhemp plants are less susceptible to herbicides, particularly upon and after reaching a height of 10 cm. This suggests that mixing glufosinate with 2,4-D can aid in the management of resistant waterhemp populations and that plants should be treated before they exceed the typical sizes targeted by label application requirements.

An Integrated Weed Management Program Controls Multiple Herbicide-Resistant Amaranthus Populations in Corn (174)

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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 in 2024 both in crop and in bare-ground situations to evaluate herbicide programs for the control of multiple herbicide-resistant *Amaranthus* spp. populations on LibertyLink® and Roundup Ready® Corn 2. Results show that integrated weed management programs consisting of preemergence followed by postemergence herbicide applications provided effective multiple herbicide-resistant *Amaranthus* spp. control on LibertyLink and Roundup Ready Corn 2.

Efficacy and Turn Time on 13,385 Acres of Ultra-High Resolution Drone Imagery for Targeted Herbicide Prescriptions with Nozzle-by-Nozzle Sprayers (175)

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In 2024 Sentera performed large scale field trials with the latest version of Sentera's weed detection and prescription generation system called Aerial WeedScout. Sentera has developed an ultra-high resolution imaging system capable of detecting weeds as small as 6 mm (0.25 in) in size that can be mounted and operated on commonly available drones, capture imagery of an entire farm field, and deliver a weed location map with targeted spray prescription to enable a next day spray. Past attempts to create precision spray prescriptions using drone imagery have been limited by the ability of regular drone cameras to capture imagery with high enough resolution to detect small weeds and time it takes to capture, move, and process the huge volume of imagery data using traditional image processing pipelines. The primary goals of the 2024 trial program were to demonstrate: a) accuracy of small weed detection and efficacy of the targeted spray prescriptions, and b) scalability of the data collection and prescription delivery process. These goals were successfully achieved with a weed detection accuracy of >94%, a data collection rate for the drone and imaging system of >90 acres hour^{-1}, and average turnaround time the targeted spray prescription of 10 hours for prescription delivery. Collaborators reported equivalent weed control of the targeted prescription to broadcast application in the side-by-side trials. Meaningful herbicide savings were also demonstrated with potential average potential herbicide savings of 66% using the latest in individual nozzle control sprayer technology. Weed detections and potential herbicide savings matched closely with other targeted application technologies such as spray systems utilizing boom-mounted cameras. The 2024 trial fields totaled 13,385 acres (5416 ha) of small and large fields spread across the US Midwest with an average field size of about 100 acres (40 ha). Sentera focused exclusively on soybeans in 2024 and is planning to expand to corn and other crops in 2025.

The Effects of Tankmix Adjuvants on Swath, Deposition and Coverage of UAV Atomizer Spray Platforms (176)

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Unmanned aerial vehicle (UAV) spray applications are becoming more prevalent as a platform to apply agriculture sprays. Recent updates to many drones have focused on spray atomization vs. previous models with broadcast nozzles. These studies were performed to evaluate the effect(s) of tankmix adjuvants and influence on deposition and spray coverage when used with spray atomizers. Studies were conducted with a DJI T40/T50 equipped with spray atomizers. Data were collected with a swath assessment tool (Swath Gobbler), to look at swath width, downwind out of swath, percent coverage, and CV within the spray. To be considered an effective spray drone adjuvant, the product must show an increased droplet deposition and coverage, have a wide manageable swath width, reduce off target drift and reduce variability within the spray. Results showed that adjuvants do indeed effect atomization from a UAV platform, and in general increase deposition and coverage. However, not all adjuvants performed the same, and more research is needed to determine the most applicable class of adjuvants to aid in UAV platform spraying.

Opportunities and Challenges for Terrestrial Sprayer Technology in Light of Drone-Based Targeted Prescription Generation (177)

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Sentera validated logistics and accuracy of drone-based weed detection for targeted herbicide application on 13,385 soybean acres across 142 fields in 2024. Separately, Iowa State University independently validated a weed hit rate of 99%, herbicide savings of nearly 50%, and statistically equivalent yield. Sentera reported potential herbicide savings of 66% for a target spray box size of 0.25 m^2 but herbicide savings of only 22% for a spray box size of 6.4 m^2. Savings was limited because spray systems are not designed for know-before targeted application. Trimble and Ag Leader systems require conversion of a spot spray prescription to a set of field boundaries, effectively making all non-sprayed areas internal field boundaries. This approach only works for small fields with few polygons because the systems cannot process hundreds of interior field boundaries. Deere and Raven/CNH systems accept spot spray prescriptions and selectively enable nozzles to implement the prescription, but have substantial accuracy limitations requiring spray box lengths of 2 m to guarantee nozzles spray at all, and longer to ensure spray hits the target. The two largest factors in spray box length are nozzle decision rate and boom dyamics. Most GPS receivers provide location updates at 5Hz or 10Hz. Even at 10Hz, a sprayer traveling at 24 km h^{-1} travels 67 cm between GPS samples. If nozzle on/off decisions are made at only 10Hz, spray box size must be buffered by at least 67 cm. Steel spray booms are not rigid. If using the sprayer's GPS location and a lever arm offset for each nozzle, boom-tip nozzle locations will contain error on the order of 1 m. Boom movement and nozzle decision rate result in error of +/- 1.67 m, suggesting a minimum spray box length of 3.34 m. Know-before spot spray prescriptions are a new and compelling reason for spray system manufacturers to solve the boom movement and nozzle decision rate limitations. Nozzle location calculations can be improved by placing GPS receivers on the boom tips and computing individual nozzle location based on boom tip position and a boom dynamics model. Nozzle on/off decisions can be made faster by using GPS systems that update at 50 or 100Hz or by estimating position between lower rate GPS updates. To prove feasibility to the spray systems industry and to enable commercialization of Sentera's Aerial WeedScout product, Sentera is developing a spot spray control module that includes two boom-tip GPS receivers running at 100Hz and executes a know-before spot spray prescription by commanding a Capstan Pinpoint III nozzle control system on an AGCO/Fendt Rogator sprayer. Sentera is collaborating with Iowa State University to perform testing in March 2025 to determine minimum spray box capabilities of four spray systems: Deere, CNH/Raven, AGCO/Capstan, and

AGCO/Capstan/Sentera. Each system will be used in-season to execute Aerial WeedScout prescriptions in soybean (*Glycine max* L.) fields using the minimum spray box sizes determined. Sentera's desire is to encourage all spray system manufacturers to optimize their systems for know-before spot spray prescriptions and welcomes collaboration and test participation to advance that outcome.

Multidirectional Spray Deposition on Artificial Collectors Using Different Nozzle Spacings and Fan Configurations (178)

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Achieving optimal spray deposition across target surfaces, especially within complex or obstructed canopies, remains a persistent challenge in effective weed management. Ensuring adequate spray coverage is crucial for maximizing product efficacy, particularly with contact-type herbicides where deposition is essential for control. Insufficient spray deposition can compromise efficacy, reduce weed control, and increase weed recovery rates. The primary objectives of this study were to examine multidirectional spray deposition patterns using two nozzle spacings and fan configurations. Deposition patterns were tested on artificial collectors arranged within a custom-made frame, simulating obstacles. Frame enabled the evaluation of 360-degree spray exposure at 45-degree increments in vertical and cross forms of exposure, simulating diverse targets. Spray deposition was assessed using white paper (kromekote) collectors 19.4 cm^2 treated with water and a food-grade blue dye solution (3 g L^{-1}). Spray applications were adjusted to a target volume of 140 L ha^{-1} and applied at two travel velocities (3.54 m s^{-1} and 1.77 m s^{-1}) for nozzle spacings of 38.1 cm (five nozzles) and 76.2 cm (three nozzles). Two nozzle types, TT11003 (TT) and TTJ6011003 (TTJ) were tested at 276 kPa. TT nozzle was initially assessed in unidirectional spray patterns, followed by testing with alternate spray patterns (180-degree alterations) against TTJ nozzles to examine the effects of nozzle orientation on deposition. After card drying, cards were scanned at 31.5 dots mm^{-1}, and subsequently, the scans were analyzed using AccuStain 0.35 software. Despite adjustments in boom height and travel speed to keep target volume constant for the two different nozzle spacings, the 38.1 cm spacing consistently provided superior coverage compared to 76.2 cm, with an increase of about 6-10% dependent on target exposure. The TTJ (dual fan) nozzles were generally more effective than TT (single fan) nozzles, particularly in cross orientation, where they enhance deposition by covering both forward and backward areas relative to the nozzle's path. In contrast, with their single backward fan, TT nozzles showed limitations in deposition uniformity, especially in vertical orientation and with wider nozzle spacings. When comparing alternate TT against TTJ, the TTJ nozzle demonstrated superior spray deposition, especially at given angles in both cross and vertical spray patterns, often showing higher deposition values. However, performance varied by angle, indicating that TTJ may provide advantages in specific orientations but not uniformly across all conditions. Additional field-based assessments are recommended to validate these findings under more realistic scenarios, as this approach could enhance herbicide exposure within complex canopies, supporting more effective weed management.

Spray Coverage, Herbicide Deposition, and Weed Control from Glufosinate with Deposition Aids Applied using a Spray Drone (179)

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A popular trend with current spray drone applications is to include a deposition aid or drift reduction agent in the spray solution to improve spray coverage and spray quality. Previous research has mainly evaluated deposition aids with fungicides for their influence on canopy penetration and spray coverage. Experiments were conducted in three soybean field sites in 2024 to quantify the spray coverage, spray deposition, and weed control with glufosinate when applied with deposition aids in a spray drone application. Deposition aid treatments with glufosinate plus ammonium sulfate included no adjuvant, a nonionic surfactant, an oil-based adjuvant plus surfactant, a high surfactant crop oil concentrate, an organic polymer, and an experimental adjuvant used as the carrier. A water-only (no glufosinate) treatment was included as a negative control. All treatments included glufosinate (656 g ai ha^{-1}), ammonium sulfate (1.12 kg ha^{-1}), pink foam marker dye (0.375% v/v), and a fluorescent tracer dye (600 µg ml^{-1}). Treatments were applied with a DJI Agras T30 equipped with 12 TT110015 nozzles calibrated to deliver 18.7 L ha^{-1} at a height of 3 m and an assumed swath of 6 m. Oil-sensitive and acetate cards were positioned in the center of 76 cm soybean rows perpendicular to the flight path and continuous bond paper was placed halfway down the plots and perpendicular to the flight path. Five weed targets of uniform size per plot were marked for data collection on herbicide efficacy. As expected, spray coverage was greatest in the center (3 to 6%) of the spray pattern and decreased towards the edges (2 to 3%) of the spray swath with all treatments. The experimental adjuvant used as the spray carrier had the greatest spray coverage (7 to 15%) at each site compared to all other treatments. Overall spray coverage was lowest at the field site that was associated with a combination of higher air temperatures, lower relative humidity, and tailwind direction. The nonionic surfactant and oil-based adjuvant plus surfactant had the greatest deposit density. Similar to spray coverage, spray deposition was greatest in the center (75 to 123% of expected) of the spray pattern and decreased towards the outside (26 to 71%) of the spray swath with all treatments. Coefficient of variation values for spray coverage (47 to 57%), deposit density (37 to 84%), and spray deposition (56 to 77%) were calculated for treatments across the entire swath. Overall, weed control was greatest with the nonionic surfactant-based deposition aid. In general, adequate weed control was observed with glufosinate treatments, which was unexpected in a low carrier volume, low spray coverage application. Future research is justified to further investigate deposition aids that may optimize the performance of herbicides throughout the entire spray swath.

Management of Herbicide-Resistant Waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer) with Targeted Herbicide Application Technology (180)

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Limited postemergence (POST) herbicide options remain viable for conventional and high oleic soybean varieties due to the prominence of herbicide-resistant weeds and the lack of crop selectivity of many POST broadleaf herbicides. Targeted herbicide application technologies may help reduce overall crop injury from POST herbicides and, if more precise application systems are developed in the future, allow the use of a wider range of herbicide chemistries without the need for developing new herbicide-resistant crop traits. Strong residual herbicide programs and cover crops are often proposed as additional strategies to control herbicide-resistant weeds such as waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer]. A field experiment was conducted in 2024 to evaluate the effect of cereal rye and a soil residual herbicide premixture (flumioxazin + pyroxasulfone + metribuzin) applied at soybean planting on waterhemp density at the time of the POST herbicide application and subsequent spray savings using targeted application technology. POST herbicide treatments were sprayed using experimental parameters on the commercial See & Spray™ Ultimate system developed by Blue River Technology. The contact herbicides glufosinate, lactofen, and pyridate were selected for the POST application due to the potential for these herbicides to induce significant injury to glyphosate-resistant soybeans and for foliar efficacy on waterhemp. This study also evaluated waterhemp control, soybean injury, and yield loss following broadcast versus targeted herbicide applications. Using cereal rye alone as a cover crop resulted in a 40% reduction in waterhemp density at POST application compared to no cover crop (fallow). Adding a residual herbicide premixture at soybean planting resulted in a 97 to 99% reduction in waterhemp density for fallow and cereal rye plots, respectively. A robust residual herbicide program combined with targeted application technology resulted in a 44% reduction in spray volume compared with a broadcast application; integrating cereal rye into this program resulted in a 90% reduction in spray volume. Soybean plants recovered quickly from lactofen and pyridate injury, with a crop injury index equal to or less than 10% at 28 days after treatment (DAT). Glufosinate injury persisted, and soybean injury averaged 12% and 45% for plots with and without the cereal rye cover crop at 28 DAT, respectively. Waterhemp control 28 DAT ranged from 90 to 98% for all POST treatments, while cereal rye alone resulted in 65% waterhemp control. None of the POST herbicide treatments, except glufosinate, reduced soybean yield compared to the weed-free control. Thus, targeted application technologies can reduce the extent of overall soybean injury in a field by reducing the total amount of product sprayed while maintaining high levels of weed control, especially if combined with residual herbicides and cover crops. However, greater spatial precision of spray technology would be necessary before targeted sprays could be considered an alternative to developing new herbicide-resistant crop traits for herbicides that lack crop selectivity.

Evaluation of Weed Management Programs using the ONE SMART SPRAY in corn and soybean in Kansas (181)

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Integrated weed management (IWM) programs that include both soil-residual and foliar-applied herbicides are important for overall weed control in Kansas corn and soybean crops. The ONE SMART SPRAY precision sprayer has a two-tank two-boom system that provides an opportunity to apply these programs in a different way. Five herbicide programs were evaluated for a third year on the same field plots in both corn and soybean as part of a corn-soybean rotation at the Kansas State University Ashland Bottoms Research Farm near Manhattan, KS in 2024. Application programs included one-pass vs. two-pass, spot-spray only, and simultaneous broadcast residual and spot-spray foliar herbicides. Three sensor detection thresholds were compared to a traditional broadcast application. Both green-on-brown (GOB; burndown) and green-on-green (GOG; in-crop) applications were evaluated. Main plots were five herbicide programs and split plot was four thresholds: broadcast, herbicide efficacy, herbicide balanced, and herbicide savings. The experimental design was a split plot with five replications for a total of 100 plots in corn and 100 plots in soybean, each plot being 3 m wide by 40 or 45 m long. No-tillage planting and subsequent burndown applications occurred on May 28 for corn and on June 6 for soybean. This was delayed as a result of much early season rainfall and resulted in significant flushes of Palmer amaranth (*Amaranthus palmeri* S. Watson) and other summer annual grass species. Thus, no differences were observed in applied herbicide savings with GOB programs nor threshold levels across all treatments. Visual weed control ratings identified a number of Palmer amaranth plants showing no response to the selected herbicide and appeared to be resistant. Herbicide savings with GOG applications were variable across herbicide programs. No savings with broadcast applications, while spot-spray only (no residual) had much lower herbicide savings (10 to 30% in corn and 12 to 24% in soybean) than two-pass programs with residual herbicides (35 to 45% in corn and 26 to 52% in soybean). Overall weed control was best with any programs that included residual herbicide at planting or overlapping residual herbicides applied at GOB and GOG timings. The spot-spray only program only included foliar-applied herbicides and did not perform well; it would not be recommended in corn or soybean fields with known Palmer amaranth populations. The consistent message of these studies over the past three years in a corn-soybean rotation in Kansas is to include soil residual herbicides in a burndown situation followed by targeted applications of foliar herbicides as part of an IWM system.

Kansas Farmer Adoption of Targeted Herbicide Application Technology (182)

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The recent commercialization of green-on-green (GG) targeted application technology (TAT) by original equipment manufacturers (OEM) has increased the adoption of targeted spraying in North American crop fields. Specifically, one OEM reported that Kansas farmers represent approximately 16% of acres covered by GG technology in 2024, in addition to approximately 60% of fallow acres sprayed with machines equipped with GG technology. There is a growing body of literature to describe the benefits and limitations of TAT as related to weed control and herbicide use. However, limited information is available to understand the factors that contribute to farmer adoption of the technology or to describe how farmers are using the technology. To address these questions, interviews were conducted with 11 Kansas farmers using various TAT systems. Survey questions were developed using the theory of planned behavior framework and the technology acceptance model. Interviews were recorded and the audio files transcribed to facilitate analysis. The constant comparative method was used to identify themes to answer the research question. Thick, rich description and participant quotes will be shared to help ensure research rigor. Of the farmers interviewed, four use green-on-brown (GB) TAT and seven use GG TAT. All farmers viewed themselves as early adopters of technology relative to their neighbors. In addition, all viewed weed management as one of the most important aspects of farm management. Farmers using GG TAT were more concerned about applicator training/skills compared to farmers using GB TAT. One factor all farmers identified as key to successful use of TAT was an automated tendering system to increase efficiency during refills. When asked how TAT changed their operation, farmers using GG TAT mentioned decreased herbicide use and improved conversations with landlords, while farmers using GB TAT focused on the ability to reduce tillage and weed seed banks. Farmers with GG and GB TAT both view herbicide savings and improved weed control as the greatest benefits, but farmers with GB TAT also said efficiency was an important benefit. All farmers indicated the technology could be improved, but only farmers with GG TAT cited cost as a limitation. These interviews also highlighted opportunities to advance the technology and thus increase adoption, including a better understanding of herbicide volume needed, the ability to use GG TAT in more crops, differentiating between weed species, and optimizing nozzle type and orientation to achieve the best possible coverage of target weeds.

Oral 9 – *Symposium* – Creating New Systems to Manage Weeds – A Retrospective of and Invitation from the Career of Don Wyse

Introduction and Purpose (183)

Mark Bernards*
USDA-ARS, Morris, MN

No abstract submitted.

A Retrospective of Don Wyse as a Land-Grant Scientist (184)

Scott Peters*, Nicholas Jordan*

Cornell University, Ithaca, NY, University of Minnesota, St. Paul, MN

No abstract submitted.

Developing Winter Annual Crops as a Tool to Improve Weed Management (185)

Gregg Johnson*[1], Samantha Wells[2], Debalin Sarangi[2], Mark Bernards[3]
[1]*University of Minnesota, Waseca, MN,* [2]*University of Minnesota, St. Paul, MN,* [3]*USDA-ARS, Morris, MN*

No abstract submitted.

Farmer Perspectives on Canada Thistle Management and Kernza (186)

Carmen Fernholz*
A Frame Organic Farms, Madison, MN

No abstract submitted.

Building Capacity for Change through Alliances with Legislators, NGOs, Farmers and Companies (187)

Mitch Hunter*
University of Minnesota, St. Paul, MN

No abstract submitted.

Non-Chemical Weed Control Strategies. Current Directions and Opportunities (188)

Muthukumar Bagavathiannan*
Texas A&M, College Station, TX

No abstract submitted.

Addressing the Regulatory Challenges of Incorporating new Crops into Agronomic Systems (189)

Michelle Starke*

CoverCress, Inc., St. Louis, MO

No abstract submitted.

Advancing Science through Asking Hard Questions and Debating Ideas without Being Disagreeable (190)

Phil Westra*
Colorado State University, Fort Collins, CO

No abstract submitted.

Discussion: Expanding the Weed Management Toolbox (191)

Mark Bernards*, Mitch Hunter*
USDA-ARS, Morris, MN, University of Minnesota, St. Paul, MN

No abstract submitted.

Concluding Remarks (192)

Dawn Wyse-Pester*; WinField United, River Falls, WI

No abstract submitted.

What's New in Industry *Symposium*

Keynote Address (193)

Mark Stewart*; Agriculture Future of America, Kansas City, MO

No abstract submitted.

Industry Updates (194)

Sustaining Member Company Representatives*

No abstract submitted.

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