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Weed Science Society

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The program and 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 listed in the program by subject matter with the abstract number listed in parenthesis. Abstracts are listed in numerical order followed by the author and keyword listing.

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Posters: Agronomic and Specialty Crops

†Determining Critical Period for Weed-Pumpkin Competition. Lindsey M. Orphan*, S. Alan Walters, Karla L. Gage; Southern Illinois University-Carbondale, Carbondale, IL (1)

ABSTRACT

The critical weed-free period is the duration of time crops should be kept free of weed competition to allow optimum crop growth before yield is affected. The critical weed-free period in crop management can help increase yield and economic return. Field studies were conducted in 2019 in Illinois at the Belleville Research Center (BRC) and Horticulture Research Center (HRC) in Carbondale to determine the critical period of weed competition for pumpkins (*Cucurbita pepo* var. 'Magic Wand'). Weeds were initially controlled at pumpkin planting for all treatments. Durations of weed control were: 0 (no weed control), 14, 28, 42, or 56 days after planting (DAP), or weed-free all season. Pumpkin yield and growth variables were: total pumpkin fruit weight, average fruit weight, fruit quantity, vine length, and leaf count per plant. Yield and growth variables differed by site, so sites were analyzed separately. Weed removal timings influenced weed biomass present at harvest, and weed biomass was negatively influenced by duration of weed control. However, yield did not differ between treatments ($p>0.05$) at either site. Yield and growth variables were regressed against growing degree days (GDD) for weed removal timing and weed biomass. At BRC, total pumpkin fruit weight per plot increased as the duration of weed control increased, but other yield and growth variables were not influenced by duration of weed control. Additionally, no relationship was detected ($p>0.05$) for yield and growth variables with amount of weed biomass present at harvest. At HRC, average fruit weight increased as the duration of weed control increased, but other yield and growth variables were not affected by duration of weed control. Average pumpkin fruit weight decreased in a linear manner as weed biomass increased at harvest. Since only total fruit weight and average fruit weight at BRC and HRC, respectively, were influenced by duration of weed control, this suggests that *C. pepo* was an effective competitor under the given environmental conditions. If environmental conditions were optimal early in the season, plants may have been able to establish and compete with weeds after only 14 days of early season weed control. The quadratic relationship between total and average fruit weight and duration of weed control suggests that weeding at any time, 14 through 56 DAP, produced more than treatments weeded throughout the duration of the study. Data will be examined for trends in community composition and competitive index of the weeds present throughout the study. The study will be repeated at each site in the 2020 growing season to confirm the impact of climate and resource availability on critical weed-free period required in pumpkin production.

Control of Johnsongrass and Foxtails with Post-Emergence Herbicides in Yellow and White Popcorn Hybrids. Samantha D. Isaacson*; University of Nebraska-Lincoln, Lincoln, NE (2)

ABSTRACT

One of popcorn producer's biggest challenges is grass weed control. There are a limited number of herbicides labeled in popcorn and even fewer with activity in grass weeds. Many times, herbicides will only be labeled for yellow popcorn and not white popcorn due to potential differences in herbicide sensitivity.

Johnsongrass (*Sorghum halepense*) and foxtail species are some of the hardest to control grasses for Nebraskan popcorn producers. The objective of this study was to compare the grass weed control of six post emergence herbicides and observe any herbicide sensitivity in a white variety and yellow variety of popcorn.

Field experiments were conducted near Clay Center, Nebraska in 2019. The field used had a large seedbank of yellow foxtail (*Setaria pumila*), green foxtail (*Setaria viridis*), and giant foxtail (*Setaria faberi*). Johnsongrass was broadcasted into the field in early April. Two varieties of popcorn were tested, one white and one yellow, alternating every four rows. Six different herbicides were tested with two controls, a weed-free control and weedy check control. The experiment used a strip plot design for the popcorn varieties in a randomized complete block design in the columns and a row-column blocking design for the herbicide treatments. The herbicides were applied as a randomized complete block design within the four replicates and as an incomplete block design in the column (the column was denoted as the pair of yellow and white popcorn varieties). Weed biomass and weed density of all grass weed species were recorded eight and eleven weeks after planting. Yield was also recorded.

No herbicide injury was observed in either popcorn variety. One HPPD inhibitor with the active ingredient tembotrione was the only herbicide that provided an acceptable level of control. The other five group 2 and group 27 herbicides had low, unacceptable levels of grass control. A possible three-way interaction between the weeds harvest date, herbicide treatment, and popcorn variety was observed.

It is clear that popcorn producers cannot rely solely on a post application herbicide for grass control. Popcorn producers must use an integrated weed management approach in order to achieve acceptable levels weed control.

†Pollen Viability and Fruit Set in Tomato Exposed to Sublethal Rates of Dicamba and 2,4-D. Sarah E. Dixon*, Reid J. Smeda; University of Missouri, Columbia, MO (3)

ABSTRACT

Extreme sensitivity of tomato (*Solanum lycopersicum*) to plant growth regulator herbicides often results with injury to vegetative tissue. However, little is known about injury to reproductive organs, which can also contribute to yield losses. The objective of a greenhouse experiment in Columbia, Missouri was to expose potted tomatoes (*Solanum lycopersicum* cv. 'Florida 91') to rates of dicamba and 2,4-D at and below a level sufficient for visual injury and describe impacts on floral development and pollen viability. As plants developed unopened blooms, applications of dicamba at 0.38 and 0.75 g ae ha^{-1} and 2,4-D at 0.27 and 0.53 g ae ha^{-1} were made to foliage. The final number of flowers on plants exposed to dicamba was similar to control plants up to 5 weeks after treatment (WAT). However, for plants exposed to 2,4-D at 0.27 and 0.53 g ha^{-1}, flower number was increased by 15 and 25%, respectively, compared to control plants. At 4 WAT, fruit set for plants exposed to dicamba at 0.38 and 0.75 g ha^{-1} was reduced by 28 and 20%, respectively. By 5 WAT, no differences were observed in the number of fruit set within treatments. No differences were observed for total or normal pollen germination, but the data suggest that injury may be possible with higher rates of 2,4-D, with 20% fewer normal pollen tubes at 0.53 g ha^{-1} compared to control plants. Flowering responses observed in this study did not result in reduced fruit weight, but reduced flower abscission in response to 2,4-D suggests a loss of control over bloom fate that was mediated by increases in plant flowering. Estimates of pollen viability indicate that pollen development was unaffected at the rates utilized in this study.

Bicyclopyrone- Crop Safety and Weed Control in Minor Crops. Timothy L. Trower*[1], Larissa L. Smith[2], Eric Rawls[3], Tom Beckett[4], Gordon Vail[4]; [1]Syngenta, Baraboo, WI, [2]Syngenta, King Ferry, NY, [3]Syngenta, Vero Beach, FL, [4]Syngenta, Greensboro, NC (4)

ABSTRACT

Bicyclopyrone is a HPPD-inhibiting (Group 27) herbicide developed by Syngenta and registered for broadleaf and grass weed control in field, sweet and popcorn. University and Syngenta studies have evaluated the crop safety and weed efficacy of preemergence and postemergence bicyclopyrone applications in various minor crops. Preemergence applications of 37.5 to 50 g ai ha^{-1} have exhibited good to excellent crop tolerance and acceptable broadleaf weed control in many of the crops tested. Syngenta is pursuing use labels on timothy grown for seed, watermelon, horseradish and strawberry. Preemergence applications for onion grown in muck soils is also under evaluation.

†Impact of Adjuvants on Rainfastness in Sugar Beets. Vinicius Velho*[1], David Mettler[2], Jeffrey A. Golus[1], Barbara Vukoja[1], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Southern Minnesota Beet Sugar Cooperative, Renville, MN (5)

ABSTRACT

A good application has the objective to place the agrochemical in a determined target as effectively as possible. The success of a chemical product does not rely only on its toxicity to the determined target, but also on a series of variables such as retention, persistence, and fundamentally the technology used in the application. Using adjuvants when spraying can optimize physicochemical characteristics of the spray solution and increase efficiency. One of the factors for a successful application is the retention of the active ingredient on the leaf despite adverse environmental factors such as rain. The objective of this study was to evaluate adjuvants influence on rainfastness in sugar beets leaves (*Beta vulgaris*). This study had six different adjuvants, four stickers and two deposition aids. Solutions included 1,3,6,8-pyrene tetrasulfonic acid tetra sodium salt (PTSA) as a fluorescent tracer at 600 ppm. Rain was simulated using a single nozzle spray chamber with a fertilizer nozzle delivering 12.4, 25.4 and 50.8 mm of rain 24 hours after the plants were sprayed. Two leaves of each plant were collected and had PTSA deposition determined with fluorometric analysis. The experiment was conducted in a Completely Randomized Design with eight replications. Deposition data were subjected to analysis of variance and treatment comparisons were performed using Fisher's protected least significant difference (LSD) test ($\alpha = 0.1$). The results indicate that rain amount ($p < 0.0001$) and adjuvant ($p = 0.0821$) influenced PTSA rainfastness. Plants submitted to no rain had the higher amount of PTSA and the amount of rain received was proportional to the wash off. Also, it is possible to notice that Sticker 1 sprayed alone retained the greatest amount of PTSA on the leaves, but when sprayed in a tank mixture with Sticker 2 had loss in efficacy. Other treatments were not different from the control after being exposed to rain.

Integrating Cereal Rye for the Management of Glyphosate-Resistant Horseweed in Sugarbeet. Brian J. Stiles II*, Christy Sprague; Michigan State University, East Lansing, MI (6)

ABSTRACT

Glyphosate-resistant horseweed (*Erigeron canadensis* L.) poses as a major challenge for many Michigan sugarbeet growers. Incorporating multiple management strategies, including cover crops, may improve horseweed control. In 2019 a study was conducted in East Lansing, Michigan to evaluate the effects of fall-planted cereal rye termination time and method combined with different POST herbicide treatments on horseweed control. Cereal rye was drilled at 67 kg ha^{-1} in fall of 2018. This study was conducted as a split-plot design with cereal rye termination method and time as the main plot factors and herbicide treatments as the sub-plot factor. Cereal rye treatments included: early burndown (EBD) 14 d prior to sugarbeet planting, burndown at planting (PBD), PBD + roller, and PBD + roller crimper, a delayed burndown (DBD) 14 d after planting, and a no cover control. The burndown treatments consisted of glyphosate applied at 1.27 kg ae ha^{-1} + ammonium sulfate. The three herbicide treatments consisted of two POST applications at the 2- and 6-8 leaf sugarbeet stage. The treatments included: 1) glyphosate twice (control), 2) glyphosate (0.84 kg ae ha^{-1}) + clopyralid (0.06 kg ha^{-1}) followed by glyphosate (0.84 kg ae ha^{-1}) and 3) glyphosate (0.84 kg ae ha^{-1}) + clopyralid (0.06 kg ha^{-1}) followed by glyphosate (0.84 kg ae ha^{-1}) + clopyralid (0.11 kg ha^{-1}). Rye biomass at the time of termination was 640 and 740 kg ha^{-1} for the EBD and PBD terminations, respectively. Rye biomass at the DBD termination was 5-times higher (4,200 kg ha^{-1}). Horseweed biomass 14 d after planting (DAP) was 11 times lower where rye was planted compared with the no cover control, regardless of termination method. There was a cover crop by herbicide interaction 14 d after the last herbicide application for horseweed biomass. Horseweed biomass was lower for all the treatments, except the one application of clopyralid without a cereal rye cover crop compared with the no cover crop control. The DBD with either of the clopyralid treatments reduced horseweed biomass by 99%. At harvest, the main effect of the cereal rye cover crop reduced horseweed biomass up to 75%. There were some differences among termination methods, with the DBD, PBD, and roller crimper showing the greatest reduction in horseweed biomass. The main effect herbicide treatments showed a greater reduction in horseweed biomass with two application of clopyralid followed by clopyralid one application, followed by the control. Even though horseweed biomass was lowest in the DBD treatment, sugarbeet yield was reduced and was not different compared with the no cover control, due to reduced sugarbeet growth in the DBD. Sugarbeet yield for the EBD, roller crimper, and roller were all similar and the PBD showed the highest overall sugarbeet yield and was not different than the roller treatment. Regardless of clopyralid treatment, sugarbeet yields were the same. Integrating cereal rye for horseweed management in sugarbeet has shown some positive results. It will be important to continue to examine these strategies in the future.

†Identification and Characterization of Chlorsulfuron-Tolerant Grain Sorghum (*Sorghum biocolor*). Balaji Aravindhan Pandian*, Sathishraj Rajendran, Vara Prasad P.V., Mithila Jugulam; Kansas State University, Manhattan, KS (7)

ABSTRACT

Post-emergent grass weed control continues to be a great challenge in grain sorghum. Chlorsulfuron (Glean™) is an acetolactate synthase (ALS) – inhibitor herbicide that is effective in post-emergence control of grass and broadleaf weeds in various crops such as wheat, barley and oats, but not registered for use in sorghum because of crop injury. We identified a sorghum genotype GL-1 with elevated tolerance to chlorsulfuron from the sorghum association panel (SAP). The objectives of this study were to determine the level, as well as investigate the inheritance and mechanism of chlorsulfuron tolerance in GL-1. Chlorsulfuron dose-response (0, 1/2, 1, 2, 4, 8, 18 and, 32x of chlorsulfuron; where 1x is 18 g ai ha^{-1}) and breeding experiments were conducted using GL-1 along with BTx623 (a widely used breeding line but highly susceptible to chlorsulfuron), and commercial hybrid Pioneer 84G62. The F_1 progeny was obtained by crossing GL-1 with BTx623. *ALS* gene, the target of chlorsulfuron, was sequenced from GL-1, BTx623 and Pioneer 84G62 using a targeted sequencing approach to assess any alterations in the target site. The role of cytochrome P450 in metabolizing chlorsulfuron was also tested using malathion, a cytochrome P450 inhibitor. All the above three genotypes were pre-treated with 2000 g ai ha^{-1} of malathion 45 minutes before application of 1, 4, and 8x of chlorsulfuron (1x, same as above). The results of dose-response assay indicated that GL-1 and F_1 progeny were ~20-fold, while Pioneer 84G62 was 1.5-fold more tolerant to chlorsulfuron relative to BTx623. The results indicating the similar level of tolerance in the F_1 progeny and the parent GL-1, suggest that chlorsulfuron tolerance in sorghum is a dominant trait. Further, there were no alterations in *the ALS* gene but a significant reduction in biomass accumulation was found in sorghum plants pre-treated with malathion, indicating an involvement of cytochrome P450 based metabolism of chlorsulfuron in grain sorghum. The GL-1 genotype can potentially be used in the o development of chlorsulfuron-tolerant sorghum hybrids.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

Inzen™ Sorghum Weed Control Programs with Zest™ WDG Herbicide. Joe Armstrong*[1], Jeffrey Krumm[2], Michael Lovelace[3], David Saunders[4]; [1]Corteva Agriscience, Indianapolis, IN, [2]Corteva Agriscience, Hastings, NE, [3]Corteva Agriscience, Lubbock, TX, [4]Corteva Agriscience, Johnston, IA (8)

ABSTRACT

Inzen™ grain sorghum from Corteva Agriscience is a novel herbicide tolerance trait designed to provide producers with a new tool for postemergence grass control in grain sorghum. Five field trials were conducted in 2019 in the central and southern Great Plains regions to evaluate one- and two-pass herbicide programs in Inzen grain sorghum using nicosulfuron (Zest™ WDG, 75% active ingredient) for postemergence (POST) weed control. Treatments consisted of acetochlor + atrazine (2270 + 1120 g ai ha^{-1}) applied preemergence (PRE), acetochlor + atrazine PRE followed by (fb) nicosulfuron + atrazine (35 or 70 + 840 g ai ha^{-1}) POST, acetochlor + atrazine + nicosulfuron (2270 + 1120 + 35 g ai ha^{-1}) POST, and nicosulfuron + atrazine (35 or 70 + 840 g ai ha^{-1}) POST. Across all trials, the two-pass program of acetochlor + atrazine PRE fb nicosulfuron + atrazine POST provided ≥88% control of key grass weeds including green foxtail (*Setaria viridis*), southwestern cupgrass (*Eriochloa gracilis*), and large crabgrass (*Digitaria sanguinalis*). Similarly, two-pass PRE fb POST programs also provided ≥95% of key broadleaf weeds in these trials, including Palmer amaranth (*Amaranthus palmeri*), kochia (*Kochia scoparia*), and Russian thistle (*Salsola iberica*). While the one-pass POST treatments also provided excellent control of these broadleaf weeds, sequential PRE fb POST programs provided the best and most consistent grass weed control and is the recommended best practice for Inzen grain sorghum.

†Screening of Industrial Hemp (*Cannabis sativa*) Tolerance to Corn and Soybean Herbicides. Haleigh J. Ortmeier-Clarke*, Maxwel C. Oliveira, Nicholas J. Arneson, Shawn Conley, Rodrigo Werle; University of Wisconsin-Madison, Madison, WI (9)

ABSTRACT

In the early 1900s, Wisconsin emerged as a leading producer of industrial hemp (*Cannabis sativa*) as a fiber crop. After years of heavy regulation of cannabis through the Controlled Substances Act, the 2018 Farm Bill separated industrial hemp from marijuana. Industrial hemp is defined as *Cannabis sativa* L. with < 0.3% tetrahydrocannabinols (THC), whereas marijuana is *Cannabis sativa* L. with > 0.3 % THC. Farmers can again legally cultivate industrial hemp, which has led to many questions including best management practices, especially surrounding weed management. Currently, there are no herbicides registered for use on industrial hemp in the United States. The objective of this study is to evaluate the response of industrial hemp to commonly used corn and soybean herbicides at different doses. The dose-response greenhouse study was conducted in a RCBD (3 replications) with two cultivars (X-59 and CRS-1) x 23 pre- and 21 post-emergence corn and soybean herbicides x 7 rates (0.125x, 0.25x, 0.5x, 0.75x, 1x,2x, and 4x the label rate of each herbicide). Two runs for each experiment were conducted. Visual evaluation and biomass were collected at 21 and 28 days after application for post- and pre-emergence applications, respectively. The data from this study is still being analyzed and will be presented at the North Central Weed Science Society Annual Meeting in December 2019. Preliminary analyses indicate that industrial hemp is sensitive to most corn and soybean herbicides tested herein other than Group 1 herbicides (ACCase-inhibitors). Results from this study will allow producers to better understand industrial hemp sensitivity to commonly used corn and soybean herbicides, with particular focus on estimating the response to drift from adjacent fields, carryover from previous growing seasons, and control of volunteer plants in subsequent years.

Posters: Agronomic Crops I - Corn

†Response of Corn to Low Doses of Paraquat and Fomesafen Using Different Carrier Volumes. Raquel B. Moreira*[1], Bruno C. Vieira[1], Benjamin P. Sperry[2], Dan Reynolds[3], Jeffrey A. Golus[1], Ana Clara Gomes[1], J. Connor Ferguson[3], Ulisses R. Antuniassi[4], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Florida, Gainesville, FL, [3]Mississippi State University, Starkville, MS, [4]UNESP, Sao Paulo, Brazil (10)

ABSTRACT

Contact herbicides require greater coverage to maximize efficacy. Decreasing droplet size to achieve greater coverage increases the drift potential. Herbicide concentration within droplets could influence herbicide activity, especially on drift simulation studies where lower herbicide concentrations are applied at higher carrier volumes. The objective of this study was to investigate corn response to paraquat and fomesafen applications at different rates with variable (concentrated) and constant (diluted) carrier volumes. Fomesafen and paraquat dose response studies were conducted at the Pesticide Application Technology Laboratory (University of Nebraska-Lincoln, West Central Research and Extension Center, North Platte, NE). V1 and V3 corn plants were sprayed with fomesafen, paraquat, and fomesafen + paraquat tank mixtures at different rates (1, 1/4, 1/16, 1/64 and 1/85 label rate). Fomesafen and paraquat label rates corresponded to 420 and 840 g ae ha^{-1}, respectively. NIS (0.25% v v^{-1}) (Induce®) and water conditioner (2.5% v v^{-1}) (Class act NG®) were included in all solutions. Applications were performed using a three nozzle, research track spray chamber with TT11002 nozzles at 276 kPa with fixed carrier volumes at 187 L ha^{-1} (diluted), and variable carrier volumes (concentrated) proportionally reduced with the herbicide rate using a pulse-width modulation system (PWM) at different duty cycles. The study was conducted in two experimental runs with a completely randomized design with four replications. Plant above-ground biomass was harvested at 28 days after applications (DAP) and dried to constant weight. Plant dry weight data were analyzed using a four-parameter log logistic model with the *drc* package in R. Corn plants were more sensitive to diluted fomesafen applications. Corn at V1 growth stage required 20.8 g ha^{-1} of diluted fomesafen to 50% biomass reduction, whereas it was required 34 g ha^{-1} of concentrated fomesafen to reach 50% biomass reductions. The same trend was observed for fomesafen applications at V3, where 9.4 and 30.8 g ha^{-1} of diluted and concentrated fomesafen were required to reach 50% control, respectively. No differences were observed for corn applied with concentrated and diluted solutions of paraquat at both corn growth stages. Corn plants were very sensitive to tank mixture solution of paraquat and fomesafen, where no differences in control was identified between concentrated and diluted treatments. The utilization of PWM to simulate drift exposure could be a feasible technique to better understand drift injury potential on various sensitive crops.

Systems Approach to Weed Control in Wisconsin Corn Production. Ryan DeWerff*, Sarah V. Striegel, Maxwel C. Oliveira, Nicholas J. Arneson, Daniel H. Smith, Rodrigo Werle; University of Wisconsin-Madison, Madison, WI (11)

ABSTRACT

A recent Wisconsin Cropping Systems survey found the majority of respondents utilize a 1-pass herbicide program in corn production. Moreover, >70% of respondents complete a form of tillage on their operation, predominantly field cultivation prior to planting. As the number of herbicide-resistant weed populations increase and the natural shifts in weed species composition becomes more challenging to control with a 1-pass system, more growers are interested in rotating to different effective sites of action (SOA) and/or adopting a 2-pass system. Concerns regarding this shift are largely economic; however, risk of competition between weed and crop species contributing to yield loss and greater weed seedbank depositions may not be worth upfront reduced input costs. Field trials were established in 2018 at Arlington and Janesville, WI and in 2019 at Arlington, Brooklyn, Janesville and Lancaster, WI to determine the season-long efficacy of different system approaches containing multiple effective herbicide SOA from three collaborating companies. The study consisted of 12 treatments, plus an untreated check, comparing four approaches: 1-pass PRE, 1-pass Early POST (V2 corn growth stage), 2-pass PRE fb POST (V4), and 2-pass PRE fb POST + residual (V4). Treatments were replicated four times and organized in RCBD. End of season overall weed control ratings (%), biomass (g m^{-1}), and yield (kg ha^{-1}) were recorded. Herein we present the 2018 data from Arlington and Janesville; the 2019 data from all sites are being processed and will be presented at the conference in December 2019. All treatments provided satisfactory weed control in Arlington. However, in Janesville, 2-pass program treatments provided the best weed control. When comparing the 1-pass systems, an Early POST program resulted in better weed control than a PRE-only program. The weed spectrum present at the Janesville location (heavy infestation of *Ambrosia trifida*) is more difficult to control in comparison to the Arlington location (*Chenopodium album, Abutilon theophrasti*, and *Poaceae* species), thus, explaining the weed control differences between sites. Biomass measurements correlated well with weed control ratings for both sites. Weed control across company portfolios was comparable. There was no yield difference between the 1-pass Early POST compared to the 2-pass programs. The 2-pass program treatments enhanced weed control, reducing weed seed depositions in the seedbank that could have persisted and impacted crops in future growing seasons however did not warrant higher grain yields when compared to the 1-pass Early POST in the first year of the study.

Controlled Environment Bioefficacy Studies of Dicamba Herbicide in Dicamba-Tolerant Maize: Developing a Rating Scale to Quantify Herbicide Injury. Laura D. Barberis, Glennon J. Rogan, Daljit Singh*; Bayer Crop Science, Chesterfield, MO (12)

ABSTRACT

Dicamba tolerant maize (*Zea mays*) is the third-generation herbicide trait conferring tolerance to dicamba and glufosinate. Ecological risk assessments are part of the registration process of genetically modified crops. The herbicide bioefficacy studies are one part of the risk assessment and are undertaken to demonstrate phenotypic stability of a trait combined through conventional breeding stack of multiple transgenic traits, including herbicide tolerance. These studies are conducted to evaluate trait bioefficacy in plants developed through conventional breeding and are required in countries that regulate stacked trait crops. A series of method development studies were done in 2016 - 2017 to assess the level of injury with dicamba in conventional maize compared to dicamba tolerant maize. Conventional maize has some intrinsic tolerance to dicamba and under optimal growing conditions herbicide damage is often not observed at the recommended label rate. Therefore, a higher rate was needed to reliably observe herbicide damage on conventional maize plants. The dicamba rates used for the studies ranged from the label rate of application (0.56 kg ae ha^{-1}) to five times the label rate. Based on the method development experiments, it was found that the use of four times the label rate (2.24 kg ae ha^{-1}) rate applied at the V2 growth stage was the discriminating rate that gave a consistent injury response in conventional maize. Herbicide bioefficacy studies were conducted with dicamba tolerant stack in 2017 based on the results from the method development studies. Dicamba treatments were applied to the foliage of the plants at V2 growth stage using an enclosed track sprayer equipped with a 9501E spray tip. A non-ionic surfactant at a rate of 0.25% (v/v) was also added for optimal uptake of the herbicide. Carrier spray volume was targeted at a rate of approximately 93.5 L ha^{-1}. To reduce the environmental variability studies were conducted in a temperature-controlled growth chamber.

The overall dicamba treated induced injury of each plant was assessed relative to untreated plants 5-days after treatment using a 0-100 rating scale. A rating scale was developed based on the stem damage or leaning rated at 10% intervals as follows: 0% = no injury, 10% = slight leaning (100 - 110°), 20% = stem moderate leaning (111°- 120°), 30% = stem leaning (121 - 130°), 40% = stem leaning (131 - 150°), 50% = stem leaning (151° - 180), 60% = severe stem bending, 70-90% = stalk twisting (depending on severity), 100% = stalk death. The rating scale provided a reliable measure of the dicamba injury. The assay has been used multiple times to assess bioefficacy in stacked-trait herbicide tolerant crops where dicamba tolerance has been combined with other herbicide or insect tolerant traits, demonstrating no changes in dicamba tolerance due to combining these traits through conventional breeding. These data have been submitted to global regulatory authorities as part of the risk assessment conducted for genetically modified crops.

†Comparison of Herbicide Programs Applied PRE and/or POST for Weed Control in Corn. Adam Leise*[1], Carl Coburn[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Bayer Crop Science, Gothenburg, NE (13)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri* S. Watson) is an increasingly troublesome weed in the Midwestern United States. An extended late season emergence period makes its control difficult. Managing glyphosate-resistant Palmer amaranth requires utilizing best management practices including using multiple effective sites of action in pre- or tank-mixes, multiple applications of overlapping residual herbicides, and making herbicide applications at the correct weed sizes. A field study was conducted at the South-Central Agricultural Laboratory in Clay County Nebraska to determine the efficacy of PRE followed by POST herbicide programs on glyphosate-resistant Palmer amaranth, velvetleaf (*Abutilon theophrasti* Medik.), and foxtail spp. (*Setaria* species) control. The study was arranged in a randomized complete block design with three replications. Herbicide programs consisted of soil residual PRE herbicides alone or followed by POST herbicides in glyphosate-resistant corn. The POST applications consisted of two application dates; an early POST sprayed at 36 d after PRE, and a late POST sprayed at 48 d after PRE. At 30 d after PRE, acetochlor/atrazine, acetochlor/atrazine plus isoxaflutole, acetochlor/atrazine plus isoxaflutole/thiencarbazone-methyl, isoxaflutole/thiencarbazone-methyl plus atrazine, isoxaflutole/thiencarbazone-methyl plus acetochlor/atrazine, acetochlor/mesotrione, acetochlor/mesotrione plus atrazine, atrazine/bicyclopyrone/mesotrione/*S*-metolachlor, acetochlor/clopyralid/mesotrione plus atrazine, dimethenamid-P/saflufenacil provided 97-99% control of Palmer amaranth. The aforementioned PRE herbicides except acetochlor/atrazine, acetochlor/atrazine plus isoxaflutole/thiencarbazone-methyl, acetochlor/clopyralid/mesotrione plus atrazine provided 83-98% control of velvetleaf. The aforementioned PRE herbicides followed by POST of acetochlor/mesotrione, dicamba, dicamba/tembotrione, tembotrione/thiencarbazone-methyl, or glyphosate at 11 d after late POST controlled Palmer amaranth >86% and velvetleaf >95%. PRE followed by POST herbicide programs provided 76-99% control of foxtail spp. excluding treatments that included only dicamba as the POST. All herbicide programs achieved between 9,144 and 12,283 kg ha^{-1}. Herbicide programs consisting of PRE followed by POST applications of multiple effective sites of action provided excellent control of glyphosate-resistant Palmer amaranth, velvetleaf, and foxtail spp., protected corn yield, and followed best management practices for managing current herbicide-resistant weeds and preventing future herbicide resistance from developing.

Development of a Soilless Assay to Investigate Resistance to Preemergence Herbicides in Waterhemp (*Amaranthus tuberculatus*). Dylan R. Kerr*, Seth Strom, Aaron G. Hager, Dean E. Riechers; University of Illinois, Urbana, IL (14)

ABSTRACT

Previous research has demonstrated two multiple-resistant waterhemp (*Amaranthus tuberculatus*) populations (CHR and MCR) from Illinois displayed resistance to several Group 15 herbicides, most notably *S*-metolachlor, in the field and greenhouse. Group 15 herbicide efficacy is affected by edaphic factors such as soil type and organic matter along with application timing and amount of rainfall. The goal of this research was to limit and control potential edaphic effects on Group 15 herbicides by developing a soilless assay to characterize herbicide efficacy for controlling resistant and sensitive waterhemp populations. Dose-response experiments were conducted under greenhouse conditions with pre-germinated seeds from CHR and MCR, as well as a herbicide-sensitive population (WUS). Seeds were planted on the surface of vermiculite soaked with various *S*-metolachlor concentrations ranging from 0.015 µM to 15 µM and lightly covered with vermiculite. Pots were sub-irrigated every second day using fresh hydroponic solution without herbicide for 21 days. At the end of the 21-day experiment, seedlings were counted and above ground biomass harvested. A preliminary study was conducted to calculate the effective dose causing a 50% reduction in survival (LD_{50}), which were 0.40 µM, 0.55 µM, 0.04 µM for CHR, MCR, ad WUS, respectively. Resistant-to-sensitive (R:S) ratios from the soilless assay were 9.0 for 12.6 for CHR and MCR, respectively, in comparison to WUS. Future research is planned with several plant metabolic enzyme inhibitors to investigate potential mechanism(s) and genetics of resistance to *S*-metolachlor in CHR and MCR. Results from the soilless assays support previous findings in soil-based systems and demonstrate that this soilless method is a promising alternative for studying preemergence herbicide efficacy on a relatively small scale, which could be altered to meet the requirements of many types of dose-response or physiology experiments.

†Interactions of Clethodim and Dicamba on Glyphosate-Resistant Volunteer Corn Control. Daniel de Araujo Doretto*[1], Gabrielle de Castro Macedo[1], Pedro H. Alves Correa[1], Karina Beneton[1], Vitor M. Anunciato[2], Jeffrey A. Golus[1], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]FCA/UNESP, Botucatu, Brazil (15)

ABSTRACT

Glyphosate-resistant (GR) volunteer corn (*Zea mays L.*) (VC) is a common weed escape in soybean fields, as corn is grown in rotation with soybean in much of the Midwest and to a lesser extent in the Mid-South. VC can reduce soybean yield through competition, cause problems with harvest, host insects and diseases, and contaminate soybean at harvest. The objective of this study was to evaluate the effects of this tank mixture on GRVC (F1) control at different growth stages using different droplet size spectra with and without the use of non-ionic surfactant (NIS). Greenhouse and field studies were conducted in a randomized complete block with five replications. In the greenhouse study, plants were sprayed at V2 (25 cm) and V3 (38 cm) stages, with two standard (XR and TT) and two air induction (AIXR and TTI) nozzles. Herbicide treatments were clethodim (Select Max®) alone (12.8 and 34 g ai ha^{-1}), clethodim + dicamba (12.8 + 280 and 34 g ai ha^{-1} + 280 g ae ha^{-1}) and dicamba (XtendiMax®) alone (280 g ae ha^{-1}). Solutions were sprayed with and without NIS (0.25% v v^{-1}) (R-11®) using a three-nozzle spray chamber at 276 kPa calibrated to deliver 140 L ha^{-1}. In the field study, plants were sprayed at 30-, 60- and 90-cm tall with a TTI nozzle. Herbicide treatments were clethodim alone (76.8, 102 and 136 g ai ha^{-1}), clethodim + dicamba (76.8 + 560, 102 + 560 and 136 g ai ha^{-1} + 560 g ae ha^{-1}) and dicamba alone (560 g ae ha^{-1}). Treatments were applied using a six-nozzle backpack sprayer at 276 kPa calibrated to deliver 140 L ha^{-1} and solutions were sprayed with drift control and foliar retention agent (DCFRA) (0.5% v v^{-1}) (Intact®) with and without NIS (0.25% v v^{-1}). Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test and Tukey's adjustment at $\alpha = 0.05$. Colby equation was used to determine whether the mixtures were antagonistic, synergistic, or additive. For both trials, antagonistic interaction between the herbicides was observed and clethodim efficacy was reduced when sprayed at lower rates in mixtures with dicamba. Also, the addition of NIS and DCFRA increased control. In the greenhouse, only the highest dose of clethodim (34 g ai ha^{-1} + 280 g ae ha^{-1}) did not have antagonism and provide adequate control (>70%) of the GRVC. The smallest stage of plants sprayed (V2) had greater control than the larger plants (V3), and the smaller droplet sizes (XR, TT) had greater control than the larger droplet sizes (AIXR, TTI). In the field, the highest dose of clethodim in combination with dicamba (136 g ai ha^{-1} + 560 g ae ha^{-1}) was able to overcome the antagonism providing a greater control (> 70%) of the GRVC, but only on the smallest plants (30 cm). Results showed that cutting the rate of clethodim is not a good strategy for management of GRVC and timeliness is critical for the success of this tool in the field.

Control of Multiple Herbicide-Resistant Palmer Amaranth in Enlist E3™ Corn. Vipan Kumar*[1], Rui Liu[1], Isaac N. Effertz[2], Natalie K. Aquilina[1], Taylor Lambert[1], Phillip W. Stahlman[1]; [1]Kansas State University, Hays, KS, [2]Kansas State University, Manhattan, KS (16)

ABSTRACT

A single Palmer amaranth (*Amaranthus palmeri*) population (MHR) with multiple resistance to 2,4-D (3.2-fold), glyphosate (11.8-fold), chlorsulfuron (5.0-fold), atrazine (14.4-fold), and mesotrione (13.4-fold) has recently been confirmed from central Kansas. Evolution of multiple resistant Palmer amaranth poses a serious threat to newly developed stacked trait technologies, including Enlist™ crops (tolerant to 2,4-D, glyphosate, and glufosinate). An increasing use of glyphosate and 2,4-D with the recent introduction of these Enlist™ crops may warrant greater attention. Field experiments were conducted in 2019 at Kansas State University Agricultural Research Center near Hays, KS to determine the effectiveness of various PRE followed by (*fb*) POST herbicides for controlling MHR Palmer amaranth in Enlist™ corn. The study was established in no-till dryland wheat stubble where a seedbank of MHR Palmer amaranth was uniformly established. An Enlist™ corn hybrid 'DKC62-53' was planted on May 16 using 43,040 seeds ha^{-1}. Ten different herbicide programs (two-pass) comprising PRE *fb* POST were evaluated. All PRE treatments included glyphosate at 1261 g ae ha^{-1} for controlling volunteer wheat seedlings at the time of corn planting. Treatments were arranged in a randomized complete block design, with four replications. Herbicides were applied using handheld boom sprayer calibrated to deliver 140 L ha^{-1} at 276 kPa. Data on percent visual control of MHR Palmer amaranth were recorded on biweekly interval throughout the season. Corn grain yield was estimated by harvesting middle two rows of each plot at maturity. Among all tested programs, PRE applied acetochlor + mesotrione + clopyralid plus atrazine, acetochlor + atrazine, pyroxasulfone + fluthiacet-methyl plus atrazine, bicyclopyrone + mesotrione + s-metolachlor + atrazine, acetochlor + atrazine, acetochlor + atrazine *fb* a POST tank-mixture treatment of glyphosate + 2,4-D choline + glufosinate plus s-metolachlor, glyphosate + 2,4-D choline + glufosinate plus isoxaflutole, glyphosate + 2,4-D choline + glufosinate plus acetochlor, glyphosate + 2,4-D choline + glufosinate, glyphosate + 2,4-D choline + glufosinate, glyphosate + 2,4-D choline + glufosinate, respectively, had an excellent season-long control (92 to 96%) of MHR Palmer amaranth. End-season control of MHR population was 85% with PRE applied topramezone + dimethenamid-P plus atrazine *fb* a POST treatment of glyphosate + 2,4-D choline + glufosinate. All tested herbicide programs significantly improved corn grain yields compared with the nontreated weedy check plots. These preliminary results indicate that PRE *fb* POST (two pass) programs tested in this research can proactively be utilized by the growers for effective management of MHR Palmer amaranth in Enlist™ corn.

Control of Annual Ryegrass with Spring-Applied Herbicides Prior to Seeding Corn. Nader Soltani*, Christy Shropshire, Peter Sikkema; University of Guelph, Ridgetown, ON (17)

ABSTRACT

Four field experiments were conducted over a two-year period (2017, 2018) in Ontario to determine the control of annual ryegrass (ARG) seeded in the fall of 2016 and 2017 (as a cover crop) with spring-applied glyphosate alone and in tankmixure with clethodim, fluazifop, quizalofop, sethoxydim or saflufenacil prior to seeding glyphosate-resistant corn. The doses of glyphosate needed (based on visual ratings) to provide 50, 80 and 90% control of annual ryegrass were 439, 1757 and >2700 g ae ha^{-1} at 3 weeks after treatment application (WAA); 526, 2105 and >2700 g ae ha^{-1} at 4 WAA; and 703, >2700 and >2700 g ae ha^{-1} at 6 WAA, respectively. Glyphosate (1350 g ae ha^{-1}) controlled ARG 27, 61, 77, 72 and 68% at 1, 2, 3, 4 and 6 WAA, respectively. The tankmix of glyphosate (1350 ae ha^{-1}) with clethodim (30 g ai ha^{-1}), fluazifop (125 g ai ha^{-1}), quizalofop (36 g ai ha^{-1}), sethoxydim (150 g ai ha^{-1}) or saflufenacil (25 g ai ha^{-1}) controlled ARG as much as 42, 68, 84, 84 and 80%, respectively. The doses of glyphosate needed to provide 50, 80 and 90% reduction in ARG biomass were 244, 599 and 943 g ae ha^{-1} at 4 WAA There were antagonism effects when Group 1 herbicides were added to glyphosate at 1, 2, 3, and 4 WAA, however, these antagonistic effects were not significant at 6 WAA. Reduced ARG interference with glyphosate (1350 g ae ha^{-1}) applied alone increased corn yield 61%. ARG control with the tankmixes of glyphosate (1350 ae ha^{-1}) with the Group 1 herbicides evaluated increased corn yield as much 66%. Additionally, reduced ARG interference with the tankmix of glyphosate (1350 ae ha^{-1}) + saflufenacil (25 g ai ha^{-1}) increased corn yield 69%. The best control of ARG was achieved with high doses of glyphosate and glyphosate (1350 g ae ha^{-1}) tankmixed with a Group 1 herbicide or saflufenacil.

Posters: Agronomic Crops II – Soybeans

Use of Low Tunnels to Identify Chemical Factors Influencing Dicamba Movement. Timothy C. Rice*, Shaun M. Billman; University of Missouri, Columbia, MO (18)

ABSTRACT

Off-target movement of dicamba has been problematic in agronomic systems since the introduction of dicamba-tolerant crops. Appropriate formulations, water conditioners and drift reduction agents (DRA's) are important to minimize particle and vapor drift. In Central Missouri, low tunnel experiments using dicamba sensitive soybeans allows the comparative assessment of traditional and new formulations of dicamba as well as proper adjuvants for targeted application under field conditions. Soybeans were planted in 76 cm rows and grown until plants reached V1 and V3 growth stages. Treatments consisting of dicamba and glyphosate, tank mixed with currently approved and experimental adjuvants and DRA's were applied on field soil in plastic flats. Treatments were applied off-site before flats were placed between soybean rows. PVC frames (1.5 m X 7.6 m) were constructed over two soybean rows (oriented North/South) over the center of the flats. Frames were covered by plastic with open ends and covered a distance over soybeans of 7.6 m; plastic was removed after 48 hours. Soybean height and visual injury were recorded 14 and 28 DAT. Visual Injury to soybeans at 14 DAT for dicamba mixes reached up to 27% within a distance of 3 m from the treated flats. However, the majority of injury (75%) occurred up to 1.8 m from treated soil. A mixture composed of dicamba and glyphosate salts and tank additives resulted in the highest visual injury and greatest reduction in soybean height; soybeans exposed to a mixture composed of dicamba, glyphosate and glufosinate salts and tank additives resulted in the lowest visual injury and least reduction in soybean height. Injured soybeans recovered from initial evaluations (14 DAT) to later evaluations (28 DAT). Elevated air temperatures and humidity under low tunnels can be an effective short-term medium for assessing differences in dicamba off-target movement based on formulation/adjuvant systems.

†The Influence of Simulated Dew on Dicamba Volatility and Soybean Sensitivity. Matthew J. Osterholt*, Bryan G. Young; Purdue University, West Lafayette, IN (19)

ABSTRACT

The commercialization of dicamba-resistant soybean (*Glycine max* (L.) Merr.) has increased the potential for off-target dicamba movement to sensitive crop species. While previous research has attributed certain environmental factors with increased volatility potential, little research is available on how other environmental phenomena, such as dew, can influence dicamba volatility. In addition, no research is available on whether the presence of dew influences dicamba-sensitive soybean response to dicamba vapor. As a result, a low tunnel experiment was conducted in 2019 to evaluate the influence of simulated dew on 1) dicamba volatility from dicamba-treated soybean leaf surfaces and 2) the response of sensitive soybean to dicamba vapor. The experiment was conducted utilizing a two-factor factorial in a randomized complete block design with four replications. Factor A was the presence or absence of dew applied to dicamba-resistant soybean grown in greenhouse flats. Factor B was the presence or absence of dew applied to the rows of planted dicamba-sensitive soybean under the low tunnel. Dicamba was applied at 2240 g ae ha^{-1} to the flats of dicamba-resistant soybean at a remote location and introduced to the low tunnels thereafter. The dicamba-treated soybean flats were placed in the middle of a 6.1m long plot that consisted of two rows of dicamba-sensitive soybean, spaced 76 cm apart. A plastic sheet was drawn over a tunnel structure covering the entirety of the plot. Dew events were simulated for three consecutive nights at a rate equivalent to 245 L ha^{-1}, based on the amount of dew collected from soybean at the site prior to initiating the experiment. In order to apply dew to the dicamba treated flats, the flats were extracted from the tunnel, administered a dew event utilizing a single-nozzle misting system, and replaced to their original position in the tunnel. To apply a simulated dew to the sensitive-soybean, the dicamba treated flats were extracted, dew applied to the sensitive soybean utilizing a seven-nozzle misting system hung inside the tunnel structure, and dicamba treated soybean were reinserted back into the tent. When dew was present on the dicamba-treated soybean flats, injury to the sensitive soybean at the center of the tunnel increased from 20 to 28% and height was reduced from 47 to 42 cm. When dew was present on the sensitive soybean rows, soybean injury increased from 18 to 30% and height was reduced from 48 to 40 cm. At the end of the tunnel, approximately 300 cm from the dicamba treated flats, soybean injury increased from 6 to 9% and height was reduced from 55 to 49 cm when dew was present on the dicamba-treated soybean. In addition, soybean injury was increased from 5 to 10% and height was reduced from 56 to 49 cm when dew was present on the dicamba-sensitive soybean rows. These results indicate that dew increases the volatility potential of dicamba from soybean leaves, as well as an increasing the response of sensitive soybean in the presence of dicamba vapor. This research will be repeated in 2020 and validated in controlled environment chambers.

Large-Scale Evaluation of Off-Target Movement of Dicamba in North America. Nader Soltani*[1], Maxwel C. Oliveira[2], Guiherme S. Alves[3], Rodrigo Werle[2], Greg Kruger[3], Jason K. Norsworthy[4], Christy Sprague[5], Bryan G. Young[6], Dan Reynolds[7], Peter Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Nebraska-Lincoln, North Platte, NE, [4]University of Arkansas, Fayetteville, AR, [5]Michigan State University, East Lansing, MI, [6]Purdue University, West Lafayette, IN, [7]Mississippi State University, Starkville, MS (20)

ABSTRACT

Six experiments were conducted in 2018 on field sites located in Arkansas (Proctor), Indiana (Montezuma), Michigan (Fowlerville), Nebraska (Stapleton), Ontario (Dresden), and Wisconsin (Arlington) to evaluate the off-target movement (OTM) of dicamba when applied according to label directions under large scale field conditions. The highest estimated dicamba injury in dicamba sensitive soybean was 50, 44, 39, 67, 15, and 44% injury for non-covered areas and 59, 5, 13, 42, 0, and 41% injury for covered areas during dicamba application in Arkansas, Indiana, Michigan, Nebraska, Ontario, and Wisconsin, respectively. The level of injury generally decreased non-linearly as the downwind distance increased under covered and non-covered areas at all sites. There was an estimated 10% injury in dicamba sensitive soybean at 113, 8, 11, 9, and 8 m; and estimated 1% injury to non-DR soybean at 293, 28, 71, 15, and 19 m from the edge of treated field downwind when plants were not covered during dicamba application in Arkansas, Indiana, Michigan, Ontario and Wisconsin, respectively. The horizontal dicamba deposition collectors placed at 4, 8, 16, 30, 45, 60, 75, 90, 105, and 120 m downwind from the edge of the sprayed area indicated that the dicamba deposition reduced non-linearly with distance. Based on these results, the greatest injury to dicamba sensitive soybean from off-target movement of dicamba occurred at Nebraska and Arkansas (as far as 275 m). Dicamba sensitive soybean injury was greatest adjacent to the dicamba sprayed area but, injury decreased rapidly with no injury beyond 20 m downwind or any other direction from the dicamba sprayed area in Indiana, Michigan, Ontario, and Wisconsin. The presence of soybean injury under covered and non-covered areas during the spray period for primary drift indicates that secondary dicamba movement was evident at five sites. Further research is needed to determine the exact forms of secondary movement of dicamba under different environmental conditions.

†Effects of Sublethal Doses of Dicamba in Combination with ACCase-Inhibiting Herbicides in Roundup Ready Soybean. Milos Zaric*, Guilherme S. Alves, Kasey P. Schroeder, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (21)

ABSTRACT

Prevalence in genetically modified crops has resulted in increased instance of volunteer crops following year. For example, either ear or kernel loss after corn harvest as a result may create significant problems in soybean. Volunteer corn unmanaged in soybean can result in competition for water, nutrients, light and space. Management of volunteer corn requires use of ACCase-inhibiting herbicide or another effective tool. Dicamba tank contamination can result in unintended soybean injury or symptomology even with exposure to doses thousands of times lower than the standard use rate. The objective of this study was to evaluate non-dicamba-tolerant soybean exposed to low doses of dicamba from postemergence applications of ACC-ase-inhibiting herbicides. An experiment was conducted 2018 and 2019 in a randomized complete block design with a factorial treatment arrangement with four replications. Each plot consisted of six rows of non-dicamba tolerant soybean (0.76 m apart and 10 m long). Treatments included non-treated check and five ACCase-inhibiting herbicides combined with three sub-labeled rates of dicamba as tank contaminants (0, 0.1, and 0.01% of the 560 g ae ha^{-1} label rate). The first herbicide application was performed when soybean developed third trifoliate (V_3), and second when soybeans were at the beginning stage of flowering (R_1). Treatments were applied using a CO_2 backpack sprayer with a six-nozzle boom calibrated to deliver 140 L ha^{-1} using AIXR110015 nozzles at 345 kPa. Recorded parameters included symptomatology on soybeans 28 days after application, plant height, and yield. Before analysis collected data-points for both years were combined. Soybean response was influenced by interaction of herbicide tank-mixture and dose of dicamba for all evaluated segments in both application timings. In general, soybeans were more responsive to dicamba when exposed at reproductive stage. Furthermore, results showed that visual appearance of symptoms was dependent on ACCase inhibitor applied, but also on dicamba rate used in tank-mix. Treatments that included 0.1% dicamba resulted in greater symptomology that had impact on soybean height regardless application timing. Even though that herbicide in combination with dicamba caused greater injury the effect on yield was dependent at the what growth stage soybean were exposed.

Growth and Sensitivity of Dicamba-Tolerant Soybean to Micro-Rates of 2,4-D. Stevan Z. Knezevic*, Jon Scott, Darko Jovanovic, Ivan B. Cuvaca; University of Nebraska-Lincoln, Lincoln, NE (22)

ABSTRACT

2,4-D is prone to drift. This raises a concern regarding potential damage to non 2,4-D-tolerant soybean. The objective of this study was to investigate the impact of 2,4-D micro-rates on growth and sensitivity of dicamba-tolerant (DT) soybean. A randomized complete block design with a split-plot arrangement and eight replications was used. Main plots consisted of three 2,4-D application times [second trifoliate (V2); beginning of flowering (V7/R1); and full flowering (R2)] and subplots consisted of six micro rates of 2,4-D (1/5; 1/10; 1/50; 1/100; 1/500; and 1/1000 of the label recommended dose of 1,120 g ae ha^{-1}) and a check with no herbicide applied. Visual injury assessment and plant height measurement were performed at 7, 14 and 21 days after treatment (DAT). Number of days to canopy closure was also recorded. Increase in 2,4-D dose increased soybean injury and reduced plant height regardless of application time. Soybean was 1.9- and 2.6-times more sensitive to 2,4-D injury at V2 and R2 stage, respectively, than the R1 stage; however, plant height reduction at the R1 stage was 4.4- and 2.6-fold that of the V2 and R2 stage, respectively. This reduction in plant height ultimately delayed canopy closure. For example, 0.89 g ae ha^{-1} of 2,4-D delayed canopy closure at R1 stage by 5 days and a 3.8 (3.40 g ae ha^{-1})- and 5.7 (5.09 g ae ha^{-1})-fold higher dose was required to delay canopy closure by same number of days (eg. 5 days) at the V2 and R2 stage, respectively. Leaf curling was more severe at both R1 and R2 than the V2 stage. Altogether, these results show that DT soybean is sensitive to micro-rates of 2,4-D especially at the onset of the reproductive stage (R1). Therefore, late 2,4-D applications should be avoided to prevent potential interference with pod formation and ultimately yield.

†Dicamba-Tolerant Soybean Dose-Response to Isoxaflutole Exposure. Karina Beneton*, Guiherme S. Alves, Daniel de Araujo Doretto, Arthur F. Teodoro Duarte, Ana Clara Gomes, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (23)

ABSTRACT

Crops tolerant to 4-hydroxyphenylpyruvate dioxygenase (HPPD)-inhibiting herbicides have been developed. The HPPD-tolerant traits in soybeans, used in combination with other traits or selective herbicides, gives growers an additional tool to slow the evolution of herbicide-resistant weeds. Soybeans that do not have the HPPD-tolerant traits are susceptible to injury from tank contamination and spray drift from HPPD herbicide applications which may result in injury. The objective of this study was to evaluate the effects of sublethal rates of isoxaflutole on non-HPPD-tolerant soybean with exposure at different development growth stages. A randomized complete block design with four replications in an 8 x 3 factorial arrangement was conducted in the field in two locations in Nebraska. Eight rates of isoxaflutole (0, 1.1, 2.6, 5.2, 7.9, 15.7, 31.5, and 105 g ai ha^{-1}) were sprayed at three soybean growth stages (V3, R1, and R5). A non-HPPD-tolerant soybean cultivar (AG24X7) was sowed in 76-cm row spacing at a population of 370,000 seeds ha^{-1}. Plot size was 7.6-m long and 6.1-m wide. Applications were made using a CO_2-pressurized backpack sprayer with six AIXR110015 nozzles calibrated to deliver 140 L ha^{-1} at 276 kPa. Plant height reduction at 14 days after treatment (DAT), seed weight, and yield were recorded. Data were subjected to analysis of variance and growth stages were compared to each other using Tukey's test at $\alpha = 0.05$. Dose-response curves were fitted to the data using the log-logistic function of the drc package in R software. An interaction between herbicide rate and growth stage was observed for plant height reduction and yield. Soybean plants exposed to isoxaflutole at V3 stage had greater height reduction than at reproductive stages, especially using rates greater than 7.9 g ha^{-1}. Maximum plant height reduction (63% in North Platte and 45% in Brule) at 14 DAT was observed at 105 g ha^{-1}. No difference in grain weight was observed across growth stages and rates. Yields from soybeans exposed at V3 and R1 were similar up to 15.8 g ha^{-1}. Soybeans exposed to 1.1 g ha^{-1} of isoxaflutole at vegetative and reproductive stages produced similar yields, ranging from 4682 to 4954 kg ha^{-1} in North Platte and 4649 to 4678 kg ha^{-1} in Brule. When compared to untreated soybeans, on average a 6 and 8% yield reduction was observed using the lowest rate in North Platte and Brule, respectively. These results suggest that sprayer tanks used to apply isoxaflutole must be appropriately cleaned before applications to non-HPPD-tolerant soybeans. In addition, drift reduction technologies (DRTs) should be used while spraying isoxaflutole close to areas cultivated with HPPD-sensitive soybeans, especially early in the season. Future research needs to be conducted to evaluate the most appropriate DRTs for isoxaflutole applications to mitigate injury to non-HPPD-tolerant crops without compromising the efficacy of the product in the target area.

Yield of Dicamba-Tolerant Soybean as Influenced by Micro-Rates of 2,4-D. Stevan Z. Knezevic*, Jon Scott, Darko Jovanovic, Ivan B. Cuvaca; University of Nebraska-Lincoln, Lincoln, NE (24)

ABSTRACT

Like other auxin herbicides, 2,4-D is typically associated with increased risk for drift-related damage to non-target crops. A study was conducted in 2019 near Concord, NE to investigate the impact of 2,4-D micro-rates on dicamba-tolerant (DT) soybean yield. The experiment used a randomized complete block design (RCBD) with four replications and a split-plot arrangement. Main plots consisted of three 2,4-D application times [second trifoliate (V2); beginning of flowering (V7/R1); and full flowering (R2)] and subplots consisted of six micro rates of 2,4-D (1/5; 1/10; 1/50; 1/100; 1/500; and 1/1000 of the label recommended dose of 1,120 g ae ha^{-1}) and a check with no herbicide applied. Crop injury was visually assessed at 7, 14 and 21 days after treatment (DAT). Grain yield was also collected. Increase in 2,4-D dose increased soybean injury and reduced yield. Less than 1/10 of the label recommended dose of 2,4-D caused 5-20% injury regardless of application time. V2 and R2 were 1.9- and 2.6-fold, respectively, more sensitive to 2,4-D injury than the R1 stage at 21 DAT. The effective dose of 2,4-D required to cause 5% soybean injury at 21 DAT at V2, R1 and R2 was 49.27, 94.26 and 36.59 g ae ha^{-1}, respectively. In regards to yield reduction, the V2 and R1 stages were 4.2- and 3.5-fold, respectively, more sensitive to 2,4-D than the R2 stage. Preliminary data analysis showed that dose of 2,4-D of 7.17-8.72 g ae ha^{-1} reduced soybean yield by 5% (0.2 Mg ha^{-1}) at the V2 and R1 stages. These results show that off-target movement of 2,4-D can significantly reduce soybean yield and therefore should be avoided.

†Interactions of Tank-Mix Combinations Utilized in XtendFlex Herbicide Systems. Adam L. Constine*, Christy Sprague; Michigan State University, East Lansing, MI (25)

ABSTRACT

PAPER WITHDRAWN

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

Soybean Yields as Influenced by Ultra-Micro Rates of Dicamba: Hormesis or Not? Stevan Z. Knezevic*, Jon Scott, Darko Jovanovic, Ivan B. Cuvaca; University of Nebraska-Lincoln, Lincoln, NE (26)

ABSTRACT

There are speculations that a drift of sub-lethal or ultra-low doses of dicamba herbicides to soybean can increase the yield through the phenomenon called hormesis. Thus, there is a need to evaluate the impact of ultra micro-rates of dicamba on yields of sensitive soybean. Field study was conducted in 2018 and 2019 at Concord, NE. The study was arranged as a split-plot design with ten dicamba micro-rates, 3 application times and 4 replications. Dicamba rates included 0; 1/10; 1/100; 1/1000; 1/5000; 1/10000; 1/20000; 1/30000; 1/40000 and 1/50000 of the 560 g ae ha^{-1} (label rate) of XtendiMax. The 3 application times were V2 (2nd trifoliate), R1 (beginning of flowering) and R2 (full flowering) stages of soybean development. Application of 1/5000 to 1/10 of dicamba label rate caused 20 to 80% visual injury with the greatest injury at R1. A 1/10 of the dicamba label rate could cause 23 to 78% soybean yield loss depending on the growth stage of exposure; with the greatest yield loss (78%) at the R1 stage. In general, our preliminary study suggested that there was no evidence that sub-lethal doses of dicamba could increase the yield of soybean irrespective of the growth stage of dicamba exposure, suggesting that there is no hormesis occurring.

†Extending Critical Time of Weed Removal in Dicamba-Tolerant Soybean with Residual Herbicides. Darko Jovanovic*, Stevan Z. Knezevic, Jon Scott, Ivan B. Cuvaca, Pavle Pavlovic, O. Adewale Osipitan; University of Nebraska-Lincoln, Lincoln, NE (27)

ABSTRACT

Dicamba-tolerant soybeans were developed to provide an alternative herbicide mode of action with the use of dicamba for weed control in soybean and to manage herbicide-resistant broadleaf weed species. Residual herbicides can influence how weeds compete with the crop. Thus, they can potentially extend the critical time of weed removal (CTWR) to later in the season. Field experiment was conducted in 2018 and 2019 at Haskell Ag Lab, Concord in Nebraska. The experiment was laid out in a split-plot arrangement of 28 treatments (4 herbicide regimes and 7 weed removal timings) with four replicates. The 4 herbicide regimes were different combinations of PRE and POST treatments. These combinations were: (1) No PRE with POST Roundup PowerMax® (glyphosate), (2) PRE Warrant® (acetochlor) and XtendiMAX® (dicamba) with POST Roundup PowerMax®, (3) PRE Warrant® and XtendiMax® with POST Roundup PowerMax® and XtendiMax®, and PRE Warrant Ultra® (acetochlor plus fomesafen) with POST Warrant®, Roundup PowerMax® and XtendiMax®. The 7 weed removal timings were: V1, V3, V6, R2 and R5 soybean growth stage, as well as weed free and weedy season long. The CTWR (based on 5% acceptable yield loss) started at V2 soybean stage in plots without residual herbicide application. The application of residual herbicides extended the CTWR to V4, V6 or R2 depending on the type of residual herbicide applied. The greatest extension of CTWR (R2) was achieved with the PRE application of Warant Ultra® complemented with POST application of Roundup PowerMax® tank-mixed with XtendiMax®. The least extension of CTWR (V4) was provided by PRE application of Warant® and XtendiMax® complemented with POST application of Roundup PowerMax®. In general, it can be concluded that application of residual herbicides in dicamba-tolerant soybeans clearly extended the CTWR.

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†Effect of Row Spacing and Herbicide Programs for Control of Glyphosate-Resistant Palmer Amaranth in Dicamba-Resistant Soybean in Nebraska. Shawn T. McDonald*[1], Parminder S. Chahal[1], Carl Coburn[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Bayer Crop Science, Gothenburg, NE (28)

ABSTRACT

The predominance of herbicide based weed control programs, the lack of herbicide site of action rotation, and the use of single mode of action herbicide programs has resulted in the evolution of herbicide-resistant weeds. An integrated weed management approach that includes cultural or mechanical weed control practices with effective PRE followed by (fb) POST herbicide programs needs to be used to maintain the longevity of dicamba/glyphosate-resistant soybean. Decreasing row spacing is one management tool shown to increase weed control by reducing weed emergence and increasing early season competitiveness of the soybean canopy. Field experiments were conducted in 2018 and 2019 at a dryland on-farm research site with confirmed glyphosate-resistant (GR) Palmer amaranth in South Central Nebraska. The objective of these experiments was to evaluate the integration of row spacing and PRE fb POST herbicide programs on the control of GR Palmer amaranth and the yield of dicamba/glyphosate-resistant soybean. A split-plot design was used with 15 herbicide programs as the main plot factor and two row spacings (37.5 and 75 cm) as the sub-plot factor. Soybean row spacing had no effect on Palmer amaranth control throughout the season in both years except in 2018 at 21 d after PRE (DAPRE) and 14 d after late-POST (DALPOST), 37.5-cm row spacing showed greater (77 to 86%) control compared to 75 cm (73 to 80%). At 21 DAPRE for 2018 and 2019 all PRE herbicides provided 90 to 97% control and 93 to 97% control, respectively, except dicamba application which provided 49% control in 2018 and 38 to 55% control in 2019. At 21 d after early-POST (DAEPOST), PRE herbicides fb dicamba plus acetochlor POST provided 91to 98% control. PRE fb dicamba POST resulted in 79 to 92% and 15 to 74% control of Palmer amaranth in 2018 and 2019, respectively. Row spacing had no effect on Palmer amaranth density at 14 DAEPOST. Most PRE fb dicamba POST programs provided greater Palmer amaranth control compared to dicamba POST alone; however, sequential POST application of dicamba provided similar control as single dicamba application 14 DALPOST. Soybean yield was only affected by row spacing in 2019. Most PRE fb dicamba POST herbicide programs provided higher yield (3838 to 4713 kg ha^{-1}) than dicamba POST alone (3582 to 3727 kg ha^{-1}) or sequential dicamba POST applications (3619 kg ha^{-1}).

Control of Glyphosate-Resistant Palmer Amaranth in Isoxaflutole/Glufosinate/Glyphosate-Resistant Soybean. Jasmine M. Mausbach*[1], Amit J. Jhala[1], Suat Irmak[1], John Lindquist[1], Debalin Sarangi[2]; [1]University of Nebraska- Lincoln, Lincoln, NE, [2]University of Wyoming, Laramie, WY (29)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri* S. Watson) is the most problematic and troublesome weed in agronomic cropping systems in the United States. A glyphosate-resistant Palmer amaranth biotype was reported in a grower's field under corn-soybean rotation in South Central Nebraska. Soybean varieties resistant to isoxaflutole, glufosinate, and glyphosate have been developed to provide additional herbicide sites of action for the control of herbicide-resistant weeds in soybean. Isoxaflutole is a soil residual PRE herbicide previously only labeled for use in corn for the control of broadleaf weeds including Palmer amaranth. Field experiments were conducted at that site during the 2018 and 2019 growing seasons to evaluate isoxaflutole and glufosinate based herbicide programs for the management of glyphosate-resistant Palmer amaranth in isoxaflutole/glufosinate/glyphosate-resistant soybean. The experiments were laid out in a randomized complete block design with four replications including a non-treated control. At 21 d after PRE, isoxaflutole applied alone or tank-mixed with sulfentrazone/pyroxasulfone, flumioxazin/pyroxasulfone, or imazethypyr/saflufenacil/pyroxasulfone provided 86 to 99% control. However, a single PRE application of isoxaflutole provided 41 and 37% control, and 63 and 10% control when followed by a POST of isoxaflutole in 2018 and 2019, respectively, 14 d after early-POST. Similarly, an early-POST of glufosinate alone provided 94 to 96% control in 2018 and 75% control in 2019, 14 d after early-POST. When glufosinate was applied POST with or without a PRE herbicide a density reduction of 89 to 100% in 2018 and 58 to 100% in 2019 was achieved 14 d after early-POST. At 21 d after late-POST, isoxaflutole PRE or isoxaflutole PRE followed by isoxaflutole early-POST provided 10% and 52% control in 2018, respectively, and provided no control for both herbicide programs in 2019. All PRE herbicides followed by single or sequential applications of glufosinate provided 80 to 99% control 21 d after late-POST in 2018. However, in 2019 PRE applications of isoxaflutole alone, imazethapyr/saflufenacil/pyroxasulfone, and isoxaflutole tank-mixed with imazethapyr/saflufenacil/pyroxasulfone followed by a single POST application of glufosinate only provided 34, 78, and 61% control compared with the 88 to 93% control for the other PRE herbicides followed by single of sequential applications of glufosinate. No soybean injury was observed from any herbicide program. Most herbicide programs provided similar yields to the non-treated control in 2018; however, isoxaflutole tank-mixed with sulfentrazone/pyroxasulfone PRE followed by glufosinate early-POST provided a greater yield of 2,294 kg ha^{-1} compared to other herbicide programs and the non-treated control (954 to 1,037 kg ha^{-1}). In 2019 most herbicide programs provided higher yields than the non-treated control; isoxaflutole followed by sequential glufosinate POST applications and sequential POST applications of glufosinate without PRE resulted in the highest yields of 4,282 and 4,227 kg ha^{-1}, respectively. Glufosinate alone applied POST and isoxaflutole tank-mixed with glufosinate applied POST had lower yields than the non-treated control (2,129 kg ha^{-1}) at 2,038 and 2,033 kg ha^{-1}, respectively. The results from this study indicate that there are herbicide programs available for effective control of glyphosate-resistant Palmer amaranth in isoxaflutole/glufosinate/glyphosate-resistant soybean.

†Effect of Application Timing of a Premix of Dicamba and Pyroxasulfone for Weed Control in Dicamba-Resistant Soybean. Ethann R. Barnes[1], Will Neels*[1], Kapler Brady[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]BASF, Eagle, NE (30)

ABSTRACT

Herbicide-resistant weeds are a major management problem for row crop producers in Nebraska. A number of weed populations have developed resistance to glyphosate and/or ALS-inhibiting herbicides. Dicamba-resistant soybean were introduced in 2017 allowing the use of dicamba in weed management programs. Use of multiple herbicide sites of action can delay the development of herbicide-resistant weed populations including resistance to dicamba. Dicamba-resistant weeds pose a real threat as a neighboring state has already confirmed a population of dicamba and 2,4-D resistant palmer amaranth (*Amarathus palmeri* S. Watson). Evaluation of dicamba-based pre-mixes and tank-mixes with multiple effective sites of action is needed. Feld experiments were conducted at the University of Nebraska-Lincoln South Central Agricultural Laboratory near Clay Center, Nebraska to evaluate a pre-mix of dicamba and pyroxasulfone at different application timings. Herbicide treatments, including a non-treated control, were laid out in a randomized complete block arrangement with 4 replications. Treatments included dicamba/pyroxasulfone and other foliar active POST herbicides as PRE and POST applied to VE, V3, and V5 soybean growth stages. Weed control and soybean injury ratings were collected at 14, 21, and 28 days after PRE, VE, V3, and V5 applications. Weed density and biomass were collected 50 days after last POST application and soybean yield was harvest. PRE herbicide treatments including dicamba and pyroxasulfone provided >85% control of common waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer), Palmer amaranth, velvetleaf (*Abutilon theophrasti* Medik.), and foxtail spp. (*Setaria* spp.). 42 DAT. Dicamba/pyroxasulfone plus glyphosate applied at the VE soybean stage resulted in >90% control of all aforementioned weed species 28 DAT. PRE herbicide treatments including dicamba and pyroxasulfone followed by dicamba plus glyphosate at the V3 soybean stage provided >88% control of all weed species. Dicamba/pyroxasulfone PRE followed by dicamba/pyroxasulfone at V3 provided 99% control of common waterhemp, Palmer amaranth, and velvetleaf 38 DAT; however, provided 0 to 76% control of foxtail spp. Dicamba/pyroxasulfone plus glyphosate at VE soybean stage followed by glyphosate alone or in tank mixture at the V5 soybean stage resulted in >96% control of all weed species in 2018 and >81% control in 2019 28 DAT. Applications of PRE followed by V3, VE followed by V5, and VE followed by V3 all resulted in 100% biomass reduction in 2018 and 41 to 96% biomass reduction in 2019. Yield ranged from 3939 to 4819 kg ha^{-1} in 2018 and 1417 to 1808 kg ha^{-1} in 2019 among herbicide programs with two applications. No soybean injury was observed from herbicides. This study concludes that a premix of dicamba and pyroxasulfone is an effective herbicide for controlling broadleaf weeds as PRE or POST in dicamba-resistant soybean when used in multiple application herbicide programs.

Yield and Yield Loss of Conventional Soybean as Influenced by 2,4-D. Ivan B. Cuvaca*, Jon Scott, Darko Jovanovic, Stevan Z. Knezevic; University of Nebraska-Lincoln, Lincoln, NE (31)

ABSTRACT

To stress investigations aimed at clarifying the impact of 2,4-D drift on non-2,4-D tolerant soybean, a study was conducted in 2019 near Concord, NE. Specifically, the study investigated the impact of 2,4-D micro-rates on conventional soybean yield. The experiment used a randomized complete block design with a split-plot arrangement and four replications. Main plots consisted of three 2,4-D application times [second trifoliate (V2); beginning of flowering (V7/R1); and full flowering (R2)] and subplots consisted of six micro rates of 2,4-D (1/5; 1/10; 1/50; 1/100; 1/500; and 1/1000 of the label recommended dose of 1,120 g ae ha^{-1}) and a check with no herbicide applied. Soybean injury was visually assessed at 7, 14 and 21 days after treatment (DAT), and grain was collected using a small-plot combine. In general, soybean injury increased with an increase in 2,4-D dose. R2 was more sensitive to 2,4-D injury than the V2 and R1 stages at 21 DAT. A 2,4-D dose of 39.6 g ae ha^{-1} caused 5% injury to conventional soybean at R2 stage compared with a 1.2-fold higher dose required to cause the same level of injury at both the V2 and R1 stages. In terms of yield reduction, the R1 stage was the most sensitive. Preliminary data analysis showed that 2,4-D dose of 1.97 g ae ha^{-1} reduced conventional soybean yield by 5% (0.2 Mg ha^{-1}) at the R1 stage compared with 140.6 and 24.2 g ae ha^{-1} required to cause the same yield reduction at the V2 and R2 stage, respectively. Overall, these results show that conventional soybean is more sensitive to 2,4-D at the reproductive stages and therefore preventing 2,4-D drift at such stages is crucial.

†Integrated Weed Management in No-Till Dryland Soybeans with Row Spacing, Seeding Rates and Herbicides. Natalie K. Aquilina*[1], Vipan Kumar[1], Andrew Tucker[2], Rui Liu[1], Taylor Lambert[1]; [1]Kansas State University, Hays, KS, [2]Fort Hays State University, Hays, KS (32)

ABSTRACT

Evolution and rapid spread of herbicide-resistant weeds requires the development of integrated weed management strategies for successful no-tillage (NT) dryland soybean production. Cultural practices, including crop row spacing and seeding rates can influence the timing of canopy closure and overall growth and development of both the crop and weeds. A field study was conducted at Kansas State University Agricultural Research Center near Hays, KS in 2019, to determine the effect of row spacing, seeding rates and herbicide program on weed control, weed biomass and grain yield in NT dryland soybean. The experiment was conducted in a randomized complete block design with factorial arrangement of treatments and 3 replications. Treatments included three seeding rates (250,000, 375,000 and 500,000 seeds ha^{-1}); two row spacings of 38 cm (narrow) and 76 cm (standard); and herbicide program: PRE-applied sulfentrazone + metribuzin (127 + 191 g ha^{-1}) followed by (*fb*) a POST treatment of glyphosate + dicamba (1260 + 560 g ha^{-1}) and a nontreated weedy check. A glyphosate plus dicamba-resistant soybean variety ‘AG34X7’ was planted on June 6, 2019 in a NT wheat stubble with a natural infestation of glyphosate-resistant (GR) Kochia (*Bassia scorparia*) and Palmer amaranth (*Amaranthus palmeri*). Data on percent visual control, density and biomass of the weed species and photosynthetic active radiations (PAR) were recorded at bi-weekly intervals throughout the growing season. At physiological maturity, total weed biomass was determined from the center of each plot by using a 1 m^2 quadrat. At crop maturity, five uniform soybean plants were collected from the center of each plot to determine soybean yield attributes (average number of pods plant^{-1}, 1000 seed weight, plant biomass). Soybean grain yield for each plot was also determined at harvest. Results indicated that PRE-application of sulfentrazone + metribuzin *fb* a POST treatment of glyphosate plus dicamba had excellent, season-long weed control. In the absence of any herbicide treatment, narrow row spacing and mid to high soybean seeding rates caused a reduction in total weed biomass. Soybean grain yield was influenced by the herbicide program as the treated plots had a 15% increase in grain yield compared to nontreated plots. Narrow row spacing reduced the 1000 seed weight of soybean as compared to standard row spacing (134 vs. 142 g). Overall, these preliminary results suggest that narrow row spacing (38 cm) with medium seeding rate (375,000 seeds ha^{-1}) can be integrated with effective herbicide program (PRE-fb POST) for season-long control of GR weeds in NT dryland soybean.

Conventional Soybean Growth and Sensitivity as Influenced by 2,4-D. Ivan B. Cuvaca*, Stevan Z. Knezevic, Darko Jovanovic, Jon Scott; University of Nebraska-Lincoln, Lincoln, NE (33)

ABSTRACT

With the recent launching of Enlist E3 soybean in the U.S., 2,4-D use is likely to increase. An experiment laid out in a randomized complete block design with a split-plot arrangement and eight replications was conducted to study the influence of 2,4-D on conventional soybean growth and sensitivity. Main plots consisted of three 2,4-D application times [second trifoliate (V2); beginning of flowering (V7/R1); and full flowering (R2)] and subplots consisted of six micro rates of 2,4-D (1/5; 1/10; 1/50; 1/100; 1/500; and 1/1000 of the label recommended dose of 1,120 g ae ha^{-1}) and a check with no herbicide applied. Visual injury and plant height were measured at 7, 14 and 21 days after treatment (DAT). Number of days to canopy closure was also recorded. Results showed an increase in soybean injury and reduction in plant height with increase in 2,4-D dose. Based on estimates of the effective dose of 2,4-D required to cause 5% injury, soybean sensitivity to 2,4-D was 1.2 (39.62 g ae ha^{-1})-fold higher at R2 than the V2 and R1 stages. 2,4-D dose of 6.64-11.72 g ae ha^{-1} reduced conventional soybean height by 5% (3.7 cm) regardless of application time. This reduction in plant height has ultimately delayed soybean canopy closure. A 2,4-D dose of 7.94, 1.27 and 15.31 g ae ha^{-1} delayed canopy closure by 5 days at the V2, R1 and R2 stage, respectively. In general, these results show that 2,4-D influences conventional soybean growth and sensitivity the most at the R1 stage; therefore, late-season 2,4-D drift should be avoided.

†Weed Management in Organic Soybeans Across Diverse Field Topographies. Kaleb A. Ortner*, Karen Renner, Dean Baas; Michigan State University, East Lansing, MI (34)

ABSTRACT

With a depressed commodity market and increased input costs, more farmers are transitioning acres to organic production. Crop yield in fields with diverse topographies may be variable due to differences in soil organic matter, soil surface texture and hydrology. Weed pressure may also differ across these diverse field landscapes. Since weeds are one of the major problems organic farmers face, we focused our research on determining how field topography and the seeding of cover crops during the transition period in corn influence weed management and soybean yield the following year. Corn was planted in two fields at Kellogg Biological Station in 2018 and two cover crop mixtures were interseeded at the V5 growth stage. One mixture was winter-hardy consisting of crimson clover, Dwarf Essex rape, and annual ryegrass; the other a winter-kill mixture of winter pea, tillage radish, and oats. Other treatments included a no-cover control and a traditional cover of cereal rye drilled after corn harvest. The field research was arranged as a split block design with field topography as the block and cover crop treatment as the split plot. Fields were chisel plowed in spring 2019 to terminate the cover crops ten days before planting. Soybeans were planted at 370,000 seeds ha^{-1} on June 3. Fields were rotary hoed four times beginning four days after planting and cultivated four times. In-row cultivation began 28 days after planting with a 6-row Danish S-tine field cultivator. The weed management tool in each split-plot was lifted in 4.5m x by 3 m area to create an untreated control. Soybean populations were counted prior to first cultivation to calculate stand loss from rotary hoeing. Canopy closure was measured in June and July with a light bar with linear sensors (SunScan). Weed biomass was counted and collected before harvest. Soybeans were harvested for yield and adjusted to 13% moisture. Rotary hoeing did not reduce soybean populations, and soybean populations did not differ by topography. Soybean yield was greater in field depressions at one site ($p \leq 0.05$). Annual grass density and biomass was greater in field depressions at both sites ($P \leq 0.1$). Cover crop treatments did not influence soybean population, yield, or weed density and biomass in 2019.

Effect of Growth Stage on Glyphosate-Tolerant Soybean Sensitivity to Micro-Rates of 2,4-D. Ivan B. Cuvaca*, Jon Scott, Darko Jovanovic, Stevan Z. Knezevic; University of Nebraska-Lincoln, Lincoln, NE (35)

ABSTRACT

Off-target movement of 2,4-D can cause severe injury to susceptible crops including non-2,4-D-tolerant crops. A field study was conducted in 2019 near Concord, NE to investigate the effect of growth stage on glyphosate-tolerant (GT) soybean sensitivity to micro-rates of 2,4-D. The experiment used a randomized complete block design (RCBD) with eight replications and a split-plot arrangement. Main plots consisted of three 2,4-D application times [second trifoliate (V2); beginning of flowering (V7/R1); and full flowering (R2)] and subplots consisted of six micro rates of 2,4-D (1/5; 1/10; 1/50; 1/100; 1/500; and 1/1000 of the label recommended dose of 1,120 g ae ha^{-1}) and a check with no herbicide applied. Soybean injury assessment and plant height measurements were performed at 7, 14 and 21 days after treatment (DAT). Number of days to canopy closure was also recorded. In general, increase in 2,4-D dose increased soybean injury and reduced plant height. Less than 1/10 of the label recommended dose of 2,4-D caused 5-20% injury to GT soybean regardless of application time; however, GT soybean was more sensitive to 2,4-D injury at R2 than the V2 and R1 stages. A 2,4-D dose of 44.88 g ae ha^{-1} caused 5% injury to GT soybean at the R2 stage compared with a 1.4- and 1.2-fold higher dose required to cause the same level of injury at the V2 and R1 stage, respectively. Plant height, on the other hand, was more sensitive to 2,4-D at R1 than the V2 and R2 stages. A dose of 2,4-D of 6.93 g ae ha^{-1} reduced plant height at R1 by 5% (3.7 cm) compared with a 1.5 (10.29 g ae ha^{-1}) to 1.6 (11.22 g ae ha^{-1})-fold higher dose that was required to cause the same reduction in plant height at other growth stages. Because of this increase in GT soybean injury and reduction in plant height, there was a delay in canopy closure with a 2,4-D dose of 9.76, 3.53 and 3.81 g ae ha^{-1} resulting in a 5 day delay in canopy closure at V2, R1 and R2 stage, respectively. Altogether, these results show that GT soybean is sensitive to micro-rates of 2,4-D especially at the reproductive stages.

†Soil Residual Activity of PRE-Emergence Soybean Herbicides in Wisconsin. Victor Hugo Vidal Ribeiro*[1], Maxwel C. Oliveira[1], Daniel H. Smith[1], Jose Barbosa dos Santos[2], Rodrigo Werle[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Federal University of Jequetinhonha and Mucuri, Diamantina, Brazil (36)

ABSTRACT

Early-season weed control is necessary to protect soybean yield potential. The application of a PRE-emergence herbicide at planting is a recommended strategy for the control of troublesome weed species with extended emergence window. The objective of this study was to evaluate via greenhouse bioassays the soil residual activity of several PRE-emergence soybean herbicides. Field studies were conducted at Arlington and Lancaster, WI, in 2018 and 2019 (RCBD with 4 replications per site). Herbicide treatments consisted of imazethapyr, chlorimuron, cloransulam, metribuzin, sulfentrazone, flumiozaxin, saflufenacil, acetochlor, S-metolachlor, dimethenamid, pyroxasulfone, and a nontreated control. Herbicides were sprayed according to their label rates within a day from planting using CO_2 backpack sprayer calibrated to deliver 140 L ha^{-1} of spray solution. Soil samples were collected at 0, 10, 20, 30, 40 and 50 days after treatment. Greenhouse bioassays were conducted using four bioindicator species: cereal rye (*Secale cereal* L.), radish (*Raphanus sativus* L.), Palmer amaranth (*Amaranthus palmeri* S. Wats.), and giant foxtail (*Setaria faberi* Herrm.), planted in seed trays. At 28 days after planting the bioassays, plant biomass was collected. Biomass percentage (%) for each treatment compared to the nontreated control was calculated. Soil residual activity of PRE-emergence herbicides varied across species. Pyroxasulfone and chlorimuron residual activity resulted in the highest and most persistent injury on radish. Metribuzin resulted in the highest and most persistent injury in cereal rye. For Palmer amaranth, sulfentrazone and pyroxasulfone resulted in the highest and most persistent injury whereas these two herbicides and S-metolachor were the most injurious to giant foxtail. According to our results, the residual activity varies across PRE-emergence herbicides and targeted species. These results can be of value to growers looking at herbicide options for enhanced control of small seeded weed species and reduced impact on establishment of subsequent cover crops.

Glyphosate-Tolerant Soybean Yield Loss and Yield Response to Micro-Rates of 2,4-D as Influenced by Growth Stage. Ivan B. Cuvaca*, Stevan Z. Knezevic, Darko Jovanovic, Jon Scott; University of Nebraska-Lincoln, Lincoln, NE (37)

ABSTRACT

With the introduction of 2,4-D-tolerant crops, the use of 2,4-D and the risk of drift in non-2,4-D tolerant crops including soybean are likely to increase. To understand the impact of 2,4-D drift on glyphosate-tolerant (GT) soybean, a study using a randomized complete block design with four replications and a split-plot arrangement of treatments was conducted in 2019 near Concord, NE. Main plots consisted of three 2,4-D application times [second trifoliate (V2); beginning of flowering (V7/R1); and full flowering (R2)] and subplots consisted of six micro rates of 2,4-D (1/5; 1/10; 1/50; 1/100; 1/500; and 1/1000 of the label recommended dose of 1,120 g ae ha^{-1}) and a check with no herbicide applied. Soybean injury was visually assessed at 7, 14 and 21 days after treatment (DAT). Grain yield was also collected using a small-plot combine. In general, there was an increase in soybean injury and reduction in grain yield with increase in 2,4-D dose. GT soybean was more sensitive to 2,4-D injury at R2 than V2 and R1 stages. Less than 1/10 of the label recommended dose of 2,4-D caused 5-20% injury to GT soybean. Based on estimates of the effective dose of 2,4-D required to cause 5% injury, GT soybean was 1.4- and 1.2-fold more sensitive to 2,4-D at R2 (44.88 g ae ha^{-1}) than V2 (61.78 g ae ha^{-1}) and R1 (53.12 g ae ha^{-1}) stage, respectively. This increase in GT soybean sensitivity to 2,4-D injury has ultimately resulted in a significant reduction in grain yield especially at the R2 stage. Preliminary data analysis showed that 2,4-D dose of 0.33 g ae ha^{-1} reduced GT soybean yield at R2 by 5% (0.22 Mg ha^{-1}) compared with 54.58 and 1.77 g ae ha^{-1} at the V2 and R1 stage, respectively. These results show that 2,4-D drift poses a risk to GT soybean and can result in significant yield losses; therefore, it is crucial that 2,4-D drift is prevented especially at the R2 stage.

†Utilizing Cover Crops as a Form of Weed Suppression in Auxin-Resistant Soybeans.

William G. Johnson, Connor L. Hodgskiss*; Purdue University, West Lafayette, IN (38)

ABSTRACT

Due to increasing problems with herbicide-resistant weeds, synthetic auxin-resistant soybeans were developed and released. Use of dicamba has increased substantially across the Midwest. The increase in auxin herbicide use has led to many concerns regarding off-target movement. Buffer areas ranging from 9 to 67m are required in some instances to reduce drift, and protect susceptible species. Within these buffer areas synthetic auxins cannot be used, and other methods of weed control are needed. One possible method for controlling weeds within these buffer areas could be cover crops. Research was conducted to evaluate cereal rye, a cereal rye/crimson clover 80/20 by weight mixture, and crimson clover on weed control. Cover crops were terminated at three different timings using three different herbicide strategies. Termination timings were 2 weeks before soybean planting, at soybean planting, or 1-2 weeks after soybean planting. The glyphosate (1280 g ae ha^{-1}) only herbicide strategy simulated “within buffer area” weed control. The other two herbicide strategies simulated control “outside of buffer areas” containing either 2,4-D or dicamba (1080 and 570 g ae ha^{-1} respectively) with and without the addition of a residual herbicide. The residual herbicide used for the before and at planting termination timings was chlorimuron-ethyl + flumioxazin (29 and 85 g ai ha^{-1} respectively). Acetochlor (1.48 kg ai ha^{-1}) was used at the after planting termination timing due to label restrictions on chlorimuron-ethyl + flumioxazin. Within buffer areas a late terminated cover crop containing cereal rye had the lowest weed biomass prior to a post being applied being at least 75% lower than the crimson clover. Similarly, the weed biomass outside of buffer areas in crimson clover was more variable ranging from 23 kg ha^{-1} to 448 kg ha^{-1} in 2018 compared to a cereal rye containing cove crop that never exceed a weed biomass above 27 kg ha^{-1}. The addition of a residual herbicide increased control to some extent in all timings except the after-planting termination which only reduced weed biomass 50% of the time. Delaying cover crop termination, using a cereal rye containing cover crop, and using a residual herbicide consistently reduced weed biomass both within, and outside of, buffer areas. Delaying the termination of cover crops from 2 weeks before planting to 2 weeks after planting in 2018 resulted in an average yield reduction of 36%. Caution should be used when delaying cover crop termination past soybean planting.

Sensitivity of Glufosinate-Tolerant Soybean to Micro-Rates of 2,4-D. Jon Scott*, Stevan Z. Knezevic, Darko Jovanovic, Ivan B. Cuvaca; University of Nebraska-Lincoln, Lincoln, NE (39)

ABSTRACT

2,4-D is one of the most widely used herbicides; however, there is a concern associated with its propensity to drift onto non-2,4-D tolerant crops. A study was conducted in 2019 near Concord, NE to investigate sensitivity of glufosinate-tolerant (GT) soybean to micro-rates of 2,4-D applied at contrasting growth stages. The study used a randomized complete block design (RCBD) with eight replications and a split-plot arrangement. Main plots consisted of three 2,4-D application times [second trifoliate (V2); beginning of flowering (V7/R1); and full flowering (R2)] and subplots consisted of six micro rates of 2,4-D (1/5; 1/10; 1/50; 1/100; 1/500; and 1/1000 of the label recommended dose of 1,120 g ae ha^{-1}) and a check with no herbicide applied. Soybean injury and plant height measurements were collected at 7, 14 and 21 days after treatment (DAT). Number of days to canopy closure was also recorded. Increase in 2,4-D dose significantly increased GT soybean injury and reduced plant height. Less than 1/100 of the label recommended dose of 2,4-D caused 5% injury to GT soybean irrespective of application time. GT soybean was more sensitive to 2,4-D injury at R2 than the V2 and R1 stages. 34.79 g ae ha^{-1} of 2,4-D caused 5% injury to GT soybean at R2 compared with a 1.4- and 1.8-fold higher dose required to cause the same level of injury at the V2 and R1 stage, respectively. With respect to plant height reduction, GT soybean was more sensitive to 2,4-D at V2 than the R1 and R2 stages. A 2,4-D dose of 3.9 g ae ha^{-1} reduced plant height at V2 stage by 5% (3.7 cm) compared with a 2.1- and 1.7-fold higher dose at the R1 and R2 stage, respectively. Increase in 2,4-D dose not only increased GT soybean injury and reduced plant height but also delayed canopy closure. 0.35 g ae ha^{-1} of 2,4-D delayed canopy closure of GT soybean at R2 stage by 5 days compared with a 11.9- and 8.4-fold higher dose at the V2 and R1 stage, respectively. These results show that GT soybean is sensitive to micro-rates of 2,4-D especially at the R2 stage; therefore, 2,4-D drift should be avoided especially at the reproductive stage.

†Impact of Tank Mix Partner on Solution pH and Secondary Movement of Dicamba and 2,4-D. Sarah V. Striegel*[1], Nikola Arsenijevic[2], Maxwel C. Oliveira[1], Ryan DeWerff[1], Nicholas J. Arneson[1], Shawn Conley[1], David Stoltenberg[1], Rodrigo Werle[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Nebraska-Lincoln, North Platte, NE (40)

ABSTRACT

Three low-volatility dicamba formulations were approved in 2017 for use in Roundup Ready 2 Xtend (glyphosate- and dicamba-tolerant) soybeans. The 2017, 2018, and 2019 growing seasons have culminated in numerous cases of growth regulator injury in susceptible soybeans due to instances of drift, improper sprayer boom/tank maintenance, off-label applications, and secondary movement. Concerns regarding off-target herbicide movement and neighboring crop injury can explain producers' hesitance to adopt this technology, as well as technologies recently approved such as Enlist (2,4-D-tolerant) soybeans. The objective of this study was to investigate the impact tank mix partners have on spray solution pH and secondary movement. In 2019, a number of lab experiments were conducted to evaluate the influence of dicamba, 2,4-D, glyphosate, and spray additives on solution pH. A low tunnel field experiment was conducted in 2019 in Wisconsin simulating two application times in the season (early versus late; replicated twice) organized in a RCBD with three replicates to further study secondary movement of select tank mixes; briefly, soil flats were sprayed with their respective treatment off-site and placed into low-tunnels constructed over dicamba and 2,4-D-susceptible soybeans at the V3-V4 growth stage for 48 hours. Lab experiments observed a drop in pH of at least 0.90 when glyphosate (potassium salt) was added to a mixture with dicamba or 2,4-D, whereas any additional components were found to have little impact. Low tunnel field experiments indicated greater dicamba symptomology at 28 days after flat placement for applications occurring later in the growing season, which coincided with more adverse weather conditions including air temperature >29.4 C. Inclusion of glyphosate was not found to influence dicamba symptomology. Minor symptomology was observed with 2,4-D treatments. This research further investigates application techniques and environmental considerations to mitigate potential for secondary movement of dicamba and 2,4-D herbicides when used for post-emergence weed control in soybean.

Yield and Yield Loss of Glufosinate-Tolerant Soybean as Influenced by 2,4-D. Jon Scott*, Stevan Z. Knezevic, Darko Jovanovic, Ivan B. Cuvaca; University of Nebraska-Lincoln, Lincoln, NE (41)

ABSTRACT

2,4-D applied to 2,4-D-resistant crops may drift and injure 2,4-D susceptible crops. A field study examined the influence of 2,4-D drift on yield and yield loss of glufosinate-tolerant soybean. 2,4-D drift was simulated by applying six micro-doses of 2,4-D (1/5; 1/10; 1/50; 1/100; 1/500; and 1/1000 of the label recommended dose of 1,120 g ae ha^{-1}) and a check with no herbicide to glufosinate-tolerant (GT) soybean at three contrasting growth stages[second trifoliate (V2); beginning of flowering (V7/R1); and full flowering (R2)]. Visual evaluation of GT soybean injury was conducted at 7, 14 and 21 days after treatment (DAT). GT soybean yield was also collected. Increase in 2,4-D micro-doses significantly increased GT soybean injury and reduced yield regardless of growth stage at time of 2,4-D application. 2,4-D doses between 1/100 to 1/50 of the label recommended rate caused 5-20% injury to GT soybean. GT soybean was more sensitive to 2,4-D injury at R2 than the V2 and R1 stages. 34.79 g ae ha^{-1} of 2,4-D caused 5% injury to GT soybean at R2 compared with a 1.4- and 1.8-fold higher dose required to cause the same level of injury at the V2 and R1 stage, respectively. With respect to yield reduction, the R2 stage was also the most sensitive. Preliminary data analysis showed that 2,4-D dose of 0.33 g ae ha^{-1} reduced GT soybean yield at R2 by 5% (0.2 Mg ha^{-1}) compared with a 10.3- and 26.3-fold higher dose at the V2 and R1 stage, respectively. These results clearly show that GT soybean is sensitive to 2,4-D especially at reproductive stages and therefore 2,4-D drift should be prevented in order to prevent yield losses.

†Efficacy of Glyphosate and Glufosinate Applied Sequentially and in Combination.

Reannen A. Kiley*[1], Mark Loux[1], Christy Sprague[2], Anthony F. Dobbels[1]; [1]The Ohio State University, Columbus, OH, [2]Michigan State University, East Lansing, MI (42)

ABSTRACT

The availability of multiple herbicide resistance traits in some soybean varieties allows growers to use combinations of POST herbicides that have not typically been applied together. One example is the combination of glyphosate and glufosinate that can be applied to the LLGT27 or Enlist soybeans, which have resistance to glyphosate, glufosinate, and either isoxaflutole or 2,4-D, respectively. A field study was conducted in 2019 in Ohio and Michigan to determine the effectiveness of glufosinate applied POST in combination with glyphosate or clethodim, versus sequentially, three days apart. The study was conducted in LLGT27 soybeans under conventional tillage conditions at the OARDC Western Agricultural Research Station at South Charleston, OH and the MSU Research Farm in East Lansing, MI. Herbicides were applied when weeds were 10 to 15 cm tall in Michigan, and 18 to 25 cm tall in Ohio. Herbicide rates were as follows: glyphosate - 430 to 1260 g ae ha^{-1}, glufosinate – 660 g ae ha^{-1}, clethodim – 79 and 105 g ai ha^{-1}. Weed control was evaluated at 7, 14, and 28 days after the second herbicide treatment (DAT), and weed biomass was measured at 14 DAT. Biomass did not vary among treatments at either site, with the exception of higher biomass for clethodim applied alone in Ohio due to lack of broadleaf control. In Michigan, control of broadleaf weeds ranged from 90 to 100% for any treatment that contained glyphosate or glufosinate, with the exception of one glufosinate treatment with 73% control of velvetleaf. Most effective control of annual grasses, 97 to 100%, occurred only where 1260 g ha^{-1} of glyphosate was applied alone or in combination with glufosinate, or for the sequential treatment with glyphosate applied prior to the glufosinate, regardless of rates. In Ohio, 90% or greater control of barnyardgrass occurred for clethodim and any treatment with 870 or 1260 g ha^{-1} of glyphosate, except where the glyphosate was applied following glufosinate. Control from clethodim decreased from 100%, to 70 to 86% when combined with or applied following glufosinate. Most effective control of a glyphosate-resistant giant ragweed population in Ohio generally occurred with sequential treatments of glyphosate and glufosinate, regardless of the order of application. Control of common lambsquarters was 97% for most treatments where glyphosate was applied at 870 or 1260 g ha^{-1}, but otherwise did not exceed 85%. Lambsquarters control decreased from 97 to 70% where glufosinate was applied prior to glyphosate, compared with the reverse order of application. Control of redroot pigweed ranged from 45 to 75% for any treatment containing glyphosate or glufosinate, with glufosinate least effective. Results of these trials indicate that: a) mixing glufosinate with glyphosate or clethodim can be less effective than separate applications, although increasing the glyphosate rate can compensate for reduced control when mixed; and b) the order of application can affect control, with most effective control occurring where the glyphosate or clethodim was applied prior to the glufosinate.

Comparison of Glufosinate and Glyphosate Sequential and Tank Mix Strategies for Weed Control in Soybeans Tolerant to Glufosinate and Glyphosate. Lisa M. Behnken*, Ryan P. Miller, Fritz R. Breitenbach; University of Minnesota Extension, Rochester, MN (43)

ABSTRACT

Recently developed soybean varieties resistant to both glufosinate and glyphosate provide producers an opportunity to utilize these herbicides in concert with one another. The question asked is how to best use these herbicides together, either as a tank-mix or sequentially. Tank-mixing herbicides with different mechanisms of action can result in unforeseen interactions such as antagonism and reduced weed control. This may be especially true for herbicides not generally used in tank-mixtures, such as glufosinate and glyphosate. These two herbicides must reach their target site in different ways, glufosinate as a contact–type herbicide and glyphosate as a systemic-type herbicide. The questions asked are, will these two herbicides work together to effectively control weeds or will they be antagonistic to each other resulting in reduced weed control? Farmers and Ag-professionals in Minnesota also asking in which sequence to apply glufosinate and glyphosate to achieve satisfactory results. The objective of this trial was to evaluate and demonstrate the effect on weed control when 1) glyphosate and glufosinate are tank-mixed, 2) glyphosate is first in the sequence followed by glufosinate and 3) glufosinate is first in the sequence followed by glyphosate in soybean that is resistant to both herbicides. All treatments that included glufosinate were made at 4 MPH with a tractor-mounted sprayer delivering 15 GPA at 40 PSI using 110015 TT nozzles. Treatments that contained glyphosate or glyphosate plus s-metolachlor were applied with 110015 TTI nozzles. All herbicides were applied at full-labelled rates. Weeds evaluated in this study were common waterhemp (*Amaranthus tamariscinus*), common lambsquarters (*Chenopodium album*), velvetleaf (*Abutilon theophrasti*) and grass species, primarily giant foxtail (*Setaria faberi*). Common waterhemp at this site is only Group 2 resistant. No antagonism or reduced control was observed between glufosinate and glyphosate on the weeds at this site. Sequence of postemergence application of glufosinate and glyphosate did not affect weed control results. The addition of a Group 15 residual herbicide with either glyphosate or glufosinate in the second postemergence application increased common waterhemp control 6 - 9%, respectively, October 8 rating.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

†Management of Glyphosate-Resistant Palmer Amaranth (*Amaranthus palmeri*) in 2,4-D Choline/Glufosinate/Glyphosate-Resistant Soybean. Chandrima Shyam*[1], Parminder S. Chahal[2], Mithila Jugulam[1], Amit J. Jhala[2]; [1]Kansas State University, Manhattan, KS, [2]University of Nebraska-Lincoln, Lincoln, NE (44)

ABSTRACT

Evolution of glyphosate resistance in Palmer amaranth (*Amaranthus palmeri* S. Watson) has been very economically damaging to soybean growers in the Midwest. Previously, a glyphosate-resistant (GR) population of Palmer amaranth was confirmed in a grower's field in Thayer County at Carleton, Nebraska. Field studies were conducted in 2018 and 2019 at the site to evaluate 2,4-D choline and glufosinate based herbicide programs for the management of GR Palmer amaranth in 2,4-D choline/glufosinate/glyphosate-resistant soybean. The treatments in the experiment were arranged in a randomized complete block design with four replications and the treatments included PRE only, PRE fb sequential application of a late post, PRE fb sequential application of tank mix of late POSTs, and an early POST with its sequential application as late POST, with a total of 15 treatments including nontreated control. At 14 days after PRE, all the three programs i.e., sulfentrazone + cloransulam-methyl, imazethapyr + saflufenacil + pyroxasulfone and chlorimuron ethyl + flumioxazin + metribuzin resulted in >84% control of Palmer amaranth. Early POST treatment of glufosinate and 2,4-D choline resulted in >65% control, >60% density reduction and >69% biomass reduction of Palmer amaranth at 14 days after early POST. However, glufosinate performed better than 2,4-D choline by controlling Palmer amaranth by 88%, along with 86% reduction in density. Amongst the PRE followed by late POST programs, imazethapyr + saflufenacil + pyroxasulfone fb 2,4- D choline + glufosinate and chlorimuron ethyl + flumioxazin + metribuzin fb 2,4- D choline + glufosinate performed well and resulted in 96-100% control of Palmer amaranth as well as 100% reduction in density and biomass. Except for sulfentrazone + cloransulam-methyl, all other PRE fb by late POST programs resulted in >88% control of Palmer amaranth and >89% reduction in density and >91% reduction in biomass at 14 days after late POST. Early POST fb last POST programs resulted in >85% control of Palmer amaranth and 98-99% reduction in density and biomass at 14 days after late POST. All the herbicide programs resulted in similar yields compared to the non-treated control. Higher rainfall amount received in 2019 compared to the average may have resulted in the lack of difference in the soybean yield due to different herbicide programs. These results indicate that PRE fb late POST programs as well as early POST followed by late POST programs can be used to successfully manage GR Palmer amaranth in 2,4-D choline/glufosinate/glyphosate-resistant soybean.

Does the Addition of Group 15 Herbicides Affect Soybean Response to Preplant Applications of Trifludimoxazin Plus Saflufenacil? Nicholas R. Steppig*[1], Derek M. Whalen[2], Bryan G. Young[1]; [1]Purdue University, West Lafayette, IN, [2]BASF Corporation, Seymour, IL (45)

ABSTRACT

The addition of Group 15 herbicides to preplant applications of some PPO-inhibiting herbicides has been shown to increase soybean injury in some cases. As such, research was conducted to examine the effect of including three Group 15 herbicides to preemergence (PRE) applications of the developmental PPO-inhibiting herbicide trifludimoxazin plus saflufenacil in soybean. Field trials were conducted at three Indiana locations in 2018 and 2019 at the Throckmorton Purdue Agriculture Center (TPAC), Pinney Purdue Agriculture Center (PPAC), and Davis Purdue Agriculture Center (DPAC), to include silt loam, sand, and clay loam soils, respectively. Experiments utilized a three factor factorial, randomized complete block design, with four replications. Factors included four rates of trifludimoxazin plus saflufenacil at a 1:2 ratio (6.25+12.5, 9.375+18.75, 12.5+25, and 25+50 g ai ha^{-1}), three Group 15 herbicides (*S*-metolachlor, pyroxasulfone, and acetochlor) and two varieties of soybean (Asgrow 39X7 and HiSoy 39X70). Soybean injury was highest at PPAC in 2019, where an interaction between trifludimoxazin plus saflufenacil rate and Group 15 herbicide was observed at 4 WAP. At this evaluation timing, treatments with the highest rate of trifludimoxazin plus saflufenacil with no Group 15 herbicide exhibited 23% injury, averaged across both soybean varieties. The addition of pyroxasulfone or acetochlor to the same rate of trifludimoxazin plus saflufenacil resulted in 46% and 51% injury, respectively. An interaction between trifludimoxazin plus saflufenacil and soybean variety was observed for soybean yield at PPAC in 2019, where the highest rate of trifludimoxazin plus saflufenacil reduced yield by 37% in the Asgrow variety. However, a significant variety main effect was observed at TPAC in 2019, where injury to HiSoy and Asgrow varieties was 19% and 14%, respectively, averaged across trifludimoxazin plus saflufenacil rates with and without Group 15 herbicides. An interaction between trifludimoxazin plus saflufenacil and variety was observed at PPAC in 2018, where 25+50 g ai ha^{-1} of trifludimoxazin plus saflufenacil resulted in 21% and 5% injury to Asgrow and HiSoy varieties, respectively, 4WAP. Following applications of 12.5+25 g ai ha^{-1}, injury was reduced to 10% and 4%, for Asgrow and HiSoy varieties, respectively. A similar interaction occurred at TPAC in 2018, where soybean injury following applications of the high rate of trifludimoxazin plus saflufenacil was 10% and 3% for the same varieties. Following applications of 12.5+25 g ai ha^{-1} trifludimoxazin plus saflufenacil, injury was reduced to 5% in the Asgrow variety and <3% in the HiSoy variety. Additionally, soybean injury at DPAC in 2018 was <8% at all evaluation timings. This research demonstrates that soybean injury can be influenced by a combination of factors including rate of trifludimoxazin plus saflufenacil applied, the inclusion of a Group 15 herbicide in combination with those herbicides, soybean variety, and environmental factors; however, interactions between variety and herbicide rate had the most impact on potential yield losses associated with these herbicide applications in this study.

†Comparison of Residual Waterhemp Control Using Group 15 Herbicides. Claudia R. Bland*[1], Cristin Weber[2], Brent S. Heaton[1], Mark L. Bernards[1]; [1]Western Illinois University, Macomb, IL, [2]Syngenta, Normal, IL (46)

ABSTRACT

Waterhemp (*Amaranthus tuberculatus*) is a significant weed problem in the Midwest because of the species' propensity to evolve resistance to herbicides. WSSA Group 15 herbicides are being relied upon to control waterhemp populations resistant to other herbicides. Our objective was to evaluate residual control of waterhemp using Group 15 herbicides alone and in tank-mixtures with other herbicide mechanisms of action. Experiments were conducted at the WIU Kerr Farm in Macomb, IL during the 2018 and 2019 growing season and at the Syngenta site in Clinton, IL during the 2019 growing season. All treatments were applied pre-emergence and were replicated three or four times. Group 15 herbicides *S*-metolachlor (1600 g ha^{-1}), dimethenamid-P (840 g/ha), pyroxasulfone (149 g ha^{-1}), and acetochlor (1370 g ha^{-1}), were compared to the Group 3 herbicide pendimethalin (1060 g ha^{-1}). Group 15 herbicide tank-mix partners included metribuzin, fomesafen, sulfentrazone, flumioxazin, and dicamba. By one month after application, pendimethalin provided less control of waterhemp than the Group 15 herbicides and the difference increased over time. In 2018, differences between the Group 15 herbicides were not apparent until the pre-harvest evaluation where S-metolachlor and pyroxasulfone provided greater control than dimethenamid-p. All tank-mixtures with Group 15 herbicides provided greater than 90% control pre-harvest and were not statistically different.

Residual Horseweed Control in Soybean with Isoxaflutole and Clomazone. Anthony F. Dobbels*, Mark Loux; The Ohio State University, Columbus, OH (47)

ABSTRACT

Horseweed (*Conyza canadnesis* L.) continues to be one of the most troublesome weeds in Ohio soybean, due to plasticity in emergence and essentially ubiquitous resistance to site 2 and 9 herbicides. Residual herbicides are an essential component of horseweed management programs, to provide control of plants emerging after planting through mid-season. This is especially the case in non-traited or glyphosate-resistant soybeans due to the absence of POST options for horseweed. Current residual herbicide options include metribuzin, flumioxazin, sulfentrazone, and higher rates of saflufenacil, but other possibilities include clomazone, and also mesotrione or isoxaflutole in soybeans resistant to site 27 herbicides. Two studies were conducted in no-till soybeans at the OARDC Western Agricultural Research Station at South Charleston, OH in 2018 and 2019 to compare the effectiveness of these herbicides for residual control. Studies were treated 7 days prior to soybean planting with combinations of the various residual herbicides plus glyphosate plus either 2,4-D or dicamba. In a comparison of isoxaflutole and mestorione, the isoxaflutole controlled 100% of horseweed at time of POST herbicide application in 2018, and 88 and 90% control of horseweed in 2019, at 70 and 105 g ai ha^{-1} respectively. Mesotrione applied at 105 and 180 ai ha^{-1} controlled 78 and 63% of horseweed in 2018, respectively, and 70 and 83% in 2019. Combining mesotrione or isoxaflutole with other residual herbicides active on horseweed increased control to 100% in 2018 and greater than 90% in 2019. In the second study, clomazone applied at 840 ai ha^{-1} controlled 72 and 70% of horseweed at time of POST herbicide application in 2018 and 2019, respectively. When clomazone was combined with one other residual herbicide, control increased to 80 to 95% in 2018, but did not improve control in 2019. Three-way combinations of clomazone plus metribuzin plus pendimethalin, metolachlor, or a site 14 herbicide increased control to between 95 and 100% both years. POST application of dicamba or glufosinate increased late-season control to 100% or 88 to 100%, respectively. Results of these trials indicate that isoxaflutole has enough residual activity to control most of the horseweed into late season even in the absence of an effective POST treatment. Mesotrione and clomazone, while having substantial residual activity on horseweed, would need to be combined with other residual herbicides obtain this same length of control. All three of these herbicides are suitably effective when followed with an effective POST treatment.

†Control of Protoporphyrinogen Oxidase (PPO)-Inhbitor-Resistant Waterhemp in Dicamba-Resistant Soybean. Adam Striegel*[1], Neha Rana[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Bayer Crop Science, St. Louis, MO (48)

ABSTRACT

Producers throughout the Midwest have new weed management options to control herbicide-resistant weeds because of the widespread adoption of dicamba-resistant soybean. In 2016, a population of multiple herbicide-resistant waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer) was confirmed in Eastern Nebraska. Field experiments with dicamba-resistant soybean were conducted in 2018 in a producer's field confirmed to have PPO-inhibitor-resistant waterhemp near Mead, Nebraska. The objective of this study was to evaluate 14 herbicide programs for control of PPO-inhibitor-resistant waterhemp, with PRE fb POST, POST, and POST fb POST programs laid out in a randomized complete block design with four replications. Fomesafen fb fomesafen, and sulfentrazone fb dicamba plus glyphosate provided 63 and 85% control of waterhemp, respectively, at 28 d after Late POST (L-POST). The same treatments resulted in 119 and 105 g m^{-2} biomass and 4 and 3 plants m^{-2}, respectively. Most herbicide programs containing an early POST (E-POST) or L-POST application of dicamba plus glyphosate provided >95% waterhemp control, >90% reduction in waterhemp density and biomass, and no yield loss. Results of this study indicate dicamba plus glyphosate applied at E-POST or L-POST are effective at controlling PPO-inhibitor-resistant waterhemp, but should be used in an herbicide program with a PRE herbicide to reduce the selection pressure of the POST herbicides.

Combining Cereal Rye and Herbicides for Horseweed Control. Dwight Lingenfelter*, John Wallace; Penn State, University Park, PA (49)

ABSTRACT

For the past decade or so, fall and early spring horseweed/marestail (*Erigeron canadensis* L.) management in no-till soybean systems included either herbicide applications or suppressive cover crops with varying results. However, to integrate tactics, is there a means to simultaneously utilize both? In a preliminary experiment from 2018 to 2019, fall- and spring-applied herbicides were evaluated in cereal rye (*Secale cereale* L.) to determine the impact on horseweed control and cover crop biomass in central Pennsylvania. Cereal rye was seeded at 67 kg ha^{-1} on September 27. Treatments were applied on October 19 and April 10 with a hand-held boom sprayer that delivered 140 L ha^{-1}. Herbicides included 2,4-D ester at 560 and 1120 g ai ha^{-1}, dicamba at 280 g, sulfentrazone plus metribuzin premix at 379 g, and chlorimuron plus tribenuron premix at 46 g. The premix treatments were tank-mixed with 2,4-D ester (560 g). Horseweed and rye growth stages in the fall application were cotyledon-1.5 cm in diameter and 8-10 cm (1-2 tillers), respectively, and 1.5-5 cm and 8-15 cm (7-12 tillers), respectively, in the spring application. Treatments were imposed using a RCBD and 3 replicates. Plots measured 3 m wide by 9 m long. Rye biomass and horseweed densities (plants m^2) were collected on May 15 prior to soybean planting. In general, the data revealed that all herbicides except for the sulfentrazone plus metribuzin premix in fall and spring did not significantly reduce rye biomass. Rye biomass in the untreated control treatment was 3175 kg ha^{-1}. Both the fall and spring 2,4-D alone, dicamba alone, and chlorimuron plus tribenuron premix treatments ranged from 2509-3058 kg ha^{-1} rye biomass. The sulfentrazone plus metribuzin premix reduced rye biomass to 2387 and 2266 kg in the fall and spring applications, respectively. Relative to the untreated check, horseweed density was significantly reduced (93 to 98%) in all treatments except for spring applications of 2,4-D (560 g) alone and the chlorimuron plus tribenuron premix, which resulted in 68 and 79% horseweed population reduction, respectively. These preliminary results suggest that combining a rye cover crop with fall- or spring-applied herbicides can be an effective tool to control horseweed. However, this data indicates that the low rate of 2,4-D applied in the spring might not be an effective option for horseweed control regardless of rye competition benefits. Our preliminary results show that sulfentrazone plus metribuzin reduce rye biomass regardless of application timing, which may limit horseweed suppression benefits from surface mulch following termination. Furthermore, prior to crop planting, additional management tactics will likely need to be implemented to maintain horseweed control during the growing season. Further studies will need to be conducted to document the effects of combining a cereal rye cover crop with herbicides.

†Preemergence Applications of Mesotrione for Control of ALS-Resistant Giant Ragweed in Liberty-Link GT27 Soybean. Benjamin C. Westrich*, Bryan G. Young; Purdue University, West Lafayette, IN (50)

ABSTRACT

Currently, no herbicide options in soybean production exist for effective preemergence (PRE) control of giant ragweed (*Ambrosia trifida* L.) biotypes resistant to ALS-inhibiting herbicides. As soybean varieties with resistance to some HPPD-inhibiting herbicides are now commercially available, the use of these herbicides to control problematic weeds like giant ragweed may be possible, pending herbicide registration. Therefore, field experiments were conducted in 2018 and 2019 to evaluate giant ragweed control following PRE applications of the HPPD-inhibiting herbicide mesotrione applied in factorial combination with S-metolachlor, metribuzin, and cloransulam and compared with industry standard premixes of cloransulam + sulfentrazone and flumioxazin + chlorimuron + pyroxasulfone. Experiments were conducted at two locations in central Indiana with either a low or high frequency of resistance to ALS-inhibiting herbicides (FOR) in their respective giant ragweed populations. Across all site-years, control of giant ragweed in treatments containing mesotrione was >72% at 42 days after planting (DAP), which was greater than control of any treatment without mesotrione (<49%). Control of giant ragweed from treatments including mesotrione did not decline between 21 and 42 DAP. However, control in nearly all treatments that included an ALS-inhibitor without the addition of mesotrione decreased over time. At the low-FOR location by 42 DAP, treatments with mesotrione had less giant ragweed biomass compared to any treatment without mesotrione. For all site-years, applying mesotrione alone resulted in giant ragweed biomass that was similar to applications of mesotrione combined with other herbicides. These results indicate that PRE applications of mesotrione in soybean could lead to more effective and longer lasting soil-residual control of both ALS-resistant and -sensitive giant ragweed populations compared with currently available herbicide options.

Impact of Termination Timing of Cereal Rye Cover Crop on PRE-emergence Herbicide Residual Activity and Grain Yield in Food Grade Soybeans. Nicholas J. Arneson*, Nikola Arsenijevic, Shawn Conley, Brian Mueller, Damon Smith, Rodrigo Werle; University of Wisconsin-Madison, Madison, WI (51)

ABSTRACT

Fall seeded cereal rye (*Secale cereal* L.) used as a cover crop following corn (*Zea mays*) before soybean (*Glycine max* L. Merr) has been adopted as a strategy to reduce soil erosion and suppress weeds. Typically, cereal rye is chemically terminated before soybean planting to minimize competition with the cash crop; however, some farmers are terminating at or after planting to maximize rye biomass production. The use of PRE-emergence residual herbicides (PRE) is recommended for weed control in soybean. There is concern that cereal rye intercepts and uptakes PRE herbicides which would in turn limit residual activity in the soil. A field experiment was established in southwestern Wisconsin to evaluate the impact of termination timing on the fate of a residual PRE herbicide in the soil, weed control, and grain yield in food grade soybeans. The experiment was conducted in a RCBD (4 replicates) with a treatment factorial of 2 food grade soybean cultivars (Dane and MN1410) X 3 termination timings [8 days before planting (DBP), at planting (0 DAP), and 14 days after planting (DAP)] X 2 herbicide programs (no PRE and 0.15 kg ai ha^{-1} sulfentrazone + 1.38 kg ai ha^{-1} S-metolachlor) for a total of 12 treatments. The PRE herbicide treatment was sprayed at 0 DAP across all necessary treatments. Soil samples (0-10 cm depth) were collected at 25 DAP for analytical analysis and a greenhouse bioassay evaluating residual control of Palmer amaranth (*Amaranthus palmeri*). Visual weed control and biomass was taken at 35 DAP. Termination timing had no significant effects on either S-metolachlor or sulfentrazone concentrations. There were no significant interactions between termination timing and PRE herbicide program for weed control in the field experiment, and only the 8 DBP termination resulted in acceptable weed control (>90%) which was significantly greater than the other timings ($P<0.0001$). In the greenhouse bioassay, 14 DAP + PRE resulted in 96% less Palmer biomass than 0 DAP + PRE ($P<0.0001$). Termination timing and PRE herbicide had no effect on grain yield. These results suggest that cereal rye when used as a cover crop before soybean can influence the fate of S-metolachlor and sulfentrazone which in turn can impact weed control efficacy. This study provides important preliminary information to producers in Wisconsin considering the incorporation of cereal rye as a cover crop in their crop rotation.

†Effect of Late Season Herbicide Applications on Seed Production of Glyphosate-Resistant Palmer Amaranth. Jose H. Scarparo de Sanctis*[1], Parminder S. Chahal[1], Vipan Kumar[2], Stevan Z. Knezevic[1], Amit J. Jhala[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Kansas State University, Hays, KS (52)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri* S. Watson) has become the most troublesome weed in agronomic fields in the United States. A single female Palmer amaranth can produce up to half a million seeds which will replenish the soil seed bank for future seasons. Therefore, weed management practices should be focused on reducing the total seed production of Palmer amaranth in the field. Previous literature and POST herbicide labels indicate Palmer amaranth plants should be sprayed when 10-15 cm tall to obtain the highest weed control. Extreme weather conditions such as strong winds or continuous rainfall can delay POST herbicide applications resulting is oversized plants at the time of application. Therefore, the objective of this study was to evaluate the effect of different POST herbicide programs on glyphosate-resistant (GR) Palmer amaranth control, seed production, and seed viability when applied at different soybean or Palmer amaranth growth stages in dicamba/glyphosate-resistant soybean. Herbicide programs consisted of single or sequential POST applications of glyphosate, acifluorfen, lactofen, fomesafen + fluthiacet-methyl, or dicamba at different soybean growth stages. Palmer amaranth plants averaged 9, 10.5, 12.5, 28, and 65 cm tall when sprayed at V4, V5, R1, R3, or R6 soybeans growth stages, respectively. Single and sequential POST applications of dicamba at 560 g ae ha^{-1} provided 83 to 99% Palmer amaranth control. In addition, single application of lactofen (220 g ai ha^{-1}) at R1 or sequential application at R1 and R6 growth stages controlled Palmer amaranth 80 to 82%, respectively. Conversely, single late season applications of acifluorfen (420 g ai ha^{-1}) at the R3 soybean growth stage and fomesafen + fluthiacet-methyl (182 g ai ha^{-1} + 8 g ai ha^{-1}) at the R6 and soybean stage resulted in 32 and 48% Palmer amaranth control, respectively. Palmer amaranth seed production was greatly reduced in single application of dicamba at R1 stage as well as sequential applications of dicamba resulting in 97 and 98% of seed reduction, respectively. Although not all delayed herbicide applications resulted in effective Palmer amaranth control most effectively reduced glyphosate-resistant Palmer amaranth seed production ultimately reducing the amount of glyphosate-resistant seed in the seedbank.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

Status of Herbicide-Resistant Tall Waterhemp in Iowa Corn and Soybean. Prashant Jha*, Ramawatar Yadav, Avery J. Bennett, Edward S. Dearden Jr., Ryan C. Hamberg, Iththiphonh A. Macvilay, James M. Lee, Damian D. Franzenburg; Iowa State University, Ames, IA (53)

ABSTRACT

The escalating spread of herbicide-resistant waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] populations has become a production challenge in corn/soybean-based crop rotations of Iowa and the Midwest. With the evolution of waterhemp resistance to major herbicide groups used in corn and soybean, there are a limited number of herbicide options left to control this weed. The early detection and rapid response is key to preventing further spread of resistance. In order to fulfill this goal, a state-wide survey was conducted in Iowa in fall 2019 to collect ~250 waterhemp populations (seeds) from georeferenced sites used in the 2013 survey. The objectives were to: 1) compare the temporal changes in baseline sensitivity of waterhemp populations collected in 2013 vs. 2019 to auxinic herbicides (dicamba, 2,4-D), HPPD inhibitors, PPO inhibitors, chloroacetamides, glyphosate, and glufosinate; 2) detect the level of evolved resistance in selected 2019 waterhemp populations using whole plant dose-response and molecular diagnostic assays. This research will aid in better understanding the spatial and temporal changes in waterhemp sensitivity to key herbicides used in corn and soybean production in Iowa. Results will be presented at the conference. This information will allow us to develop proactive strategies to contain further spread of herbicide resistance, more importantly populations with resistance to multiple herbicides, and understand the long-term impact of management practices in resistance evolution in waterhemp. Overall, this research will emphasize the need to implement diverse integrated weed management (IWM) programs to achieve the sustainability goal.

†Evaluation of Spectral Response and Yield of Soybean Following Herbicide Injury. Eric G. Oseland*, Mandy Bish, Kevin Bradley; University of Missouri, Columbia, MO (54)

ABSTRACT

Increased applications of synthetic auxin herbicides to 2,4-D- and dicamba-resistant soybean has resulted in an escalation in off-target injury to sensitive soybean varieties. Yield loss associated with synthetic auxin injury can be difficult to estimate as determining the level of exposure is mostly speculative. Spectral variation of injured soybean may provide a more accurate prediction of yield loss and can be quantified through the use of multispectral imaging. A field experiment was conducted in 2018 and 2019 to evaluate the relationship of various vegetative indices to soybean yield following injury from either 2,4-D or dicamba. These vegetative indices (VI) were calculated using combinations of wavelengths from the visible and near-infrared (NIR) spectrums. Soybeans were planted at three separate timings and injurious rates of 2,4-D and dicamba were applied when soybean growth stages reached R2, R1 and V3 for the early, middle, and late planting timings respectively. Dicamba was applied at 0.00056, 0.0056- and 0.056 kg ae ha^{-1} and 2,4-D at 0.0056- 0.056- and 0.56 kg ae ha^{-1}. Multispectral images were obtained using a UAV mounted 4 band camera system capturing data from the NIR (770-810 nm), red edge (730-740 nm), red (640-680 nm), and green (530-570 nm) spectrums. RGB data were obtained using a separate UAV-mounted 3 band sensor capturing red (570 nm), green (540 nm), and blue (440 nm) wavelengths. Normalized difference vegetation index (NDVI), normalized difference red edge (NDRE), and green normalized difference vegetation index (GNDVI) were calculated using multispectral data and visible atmospherically resistant index (VARI) and triangular greenness index (TGI) were calculated using RGB data. Images were processed in Pix4d and data were extracted using QGIS 2.18 from a 3-by 5 meter subplot in the center of each main plot. Single-variable linear regression models were computed separately for each growth stage and herbicide combination and R-squared values were evaluated to determine which VI are most useful in determining potential yield loss associated with synthetic auxin injury. In all cases, yield reduction was positively correlated to VI values. For soybeans injured with dicamba, VI values which incorporated the NIR spectrum were more strongly correlated with yield than VI which contained only wavelengths from the visible spectrum. Alternatively, soybeans injured with 2,4-D were most strongly correlated with the VARI index. GNDVI was most consistently correlated with yield for soybean injured with dicamba across all growth stages. Incorporating the red edge band into VI calculations did not provide any benefit for either dicamba or 2,4-D injury.

Posters: Equipment and Application Methods

Spray Solution Component Property Effects on Deposition Modeling with AgDisp. Jeffrey A. Golus*, Barbara Vukoja, Bruno C. Vieira, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (55)

ABSTRACT

The introduction of dicamba- and 2,4-D-tolerant soybeans and cotton brought with it label restrictions regarding tank-mixtures. Any product being considered for tank-mixing first needs to be tested with the dicamba or 2,4-D product according to the Label Terms and Conditions. The first step is to obtain the droplet size distribution for the tank-mixture. This droplet size distribution is then modelled for drift deposition using AGDISP to estimate drift at the appropriate buffer distance. The AGDISP model requires many inputs, among these being spray solution density and nonvolatile fraction of the spray solution. A study was conducted to evaluate the impact of these factors on drift estimation using AgDisp. Droplet size for two dicamba products and two 2,4-D products was obtained using a laser diffraction. Four nozzles (XR11004, TT11004, AIXR11004 and TTI11004) were each evaluated at 207 and 414 kPa with each of the four spray solutions to obtain eight differing droplet size distributions for each product. Each drop size distribution was then modelled through AGDISP. Density and nonvolatile fractions were varied as inputs for each distribution to see their impact on drift deposition estimation. A Random Forest analysis was conducted with R Software to determine the relative influence of each variable (nozzle, pressure, solution, density fraction, nonvolatile fraction). This analysis showed nozzle and pressure (in combination these determine droplet size distribution) were the most influential factors in drift deposition estimation. The nonvolatile fraction also contributed some influence and will need to be considered as companies develop new products for use with herbicides with tank mixture restrictions.

Spray Drift Measurements from Various Applications in a Controlled Wind Speed Environment: Pseudo-Field Study Testing. Josh Arnold, Timothy E. Lane*, Frederick Salzman; Battelle, Columbus, OH (56)

ABSTRACT

Pesticide drift studies performed in the field are time consuming, weather dependent, and costly. Conducting trials in an ambient breeze tunnel (ABT) allows for control of wind speed and direction for the duration of the study. The tunnel itself can achieve up to 12 mph wind speeds with low turbulence and variability, and can measure downwind distances up to 110 feet from the nozzle. The internal cross-sectional dimensions of the tunnel are 15 ft wide by 8 ft high. Drift potential can be accurately measured under various conditions (wind speed, temperatures, relative humidity, boom height, application rate, nozzle, etc.). Both air and deposition samples can be collected during/after the application. Soil and/or crops can also be brought into the tunnel during a study and monitored in a growth facility after exposure. In addition to the initial spray drift, subsequent volatilization can be measured for a given time period post application. An assortment of instrumentation can be used for both deposition and air concentrations downwind of the application, e.g. filter papers, glass slides, water trays, water/oil sensitive paper, monofilament lines, and PUF samplers. The ABT generates fast, accurate, and repeatable data and is inexpensive relative to in-field studies.

†Potential Nozzles and Herbicides for a UAV Pesticide Application. Trenton Houston*[1], W. C. Hoffmann[2], Jeffrey A. Golus[1], Guilherme S. Alves[1], Barbara Vukoja[1], Bruno C. Vieira[1], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Prology Consulting, College Station, TX (57)

ABSTRACT

sUAV (small unmanned aerial vehicle) applications have the potential to be efficient pesticide application platforms under conditions that are not accessible or fit for typical pesticide application equipment. Although this type of application is still under development in the U.S., sUAV pesticide applications are common in Asia, as they have replaced backpack sprayers. The use and adoption of this technology in the U.S. greatly depends on ensuring the applications are as efficient as possible. Many parameters need to be investigated to identify the best combination of application variables such as carrier volumes, nozzle, and herbicide. The objective of this research wasto investigate different application variables for a sUAV application platform. This greenhouse study was carried out at the Pesticide Application Technology Laboratory in North Platte, Nebraska at the University of Nebraska-Lincoln. The experiment was conducted in a completely randomized design with four replications in two experimental runs. Common waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer) were grown to 20-25 cm height under greenhouse conditions and sprayed in a three-nozzle spray chamber at 207 kPa. The following six herbicides were applied: formulated glyphosate, unformulated glyphosate, glufosinate, carfentrazone-ethyl, dicamba, and mesotrione. Herbicides were applied at 2.3 L ha^{-1} and 93.5 L ha^{-1} with AIXR11002, TXR8002, XR8002, and TXR8002 nozzles. Plants were harvested 28 days after treatment and dry biomass was collected. Treatment comparisons were performed using ANOVA with Fisher's least significant difference procedure at $\alpha = 0.05$. Biomass control was influenced by the interaction of carrier volume*nozzle type*herbicide solution ($p<0.0001$). The study results indicate that nozzles producing smaller droplets paired with 2.3 L ha^{-1} provided the highest level of control in general. Carfentrazone-ethyl had greater control at 2.3 L ha^{-1} than higher carrier volumes tested. Dicamba and mesotrione control were not influenced by nozzle type or carrier volume. With the exception of the XR nozzle, glufosinate applications at 93.5 L ha^{-1} had greater control than applications at 2.3 L ha^{-1}. Poor fan formation from the TXR, AIXR, and AITX nozzles at 2.3 L ha^{-1} led to weed control failures. Formulated glyphosate applied at 2.3 L ha^{-1} provided the greatest control for the TXR, AIXR, and XR nozzles, whereas applications with the AITX nozzle at 2.3 L ha^{-1} had underdeveloped spray patterns resulting in poor performance. At 2.3 L ha^{-1}, proper fan formation was not achieved with AITX and AIXR nozzles. These data reveal that sUAV pesticide applications can provide effective control levels with current formulations and nozzles, but the combinations need to be tested because some combinations did not work effectively.

Effect of Adjuvant Rates on Dicamba Physicochemical Properties and its Correlation with Droplet Size. Gabrielle de Castro Macedo*[1], Jesaelen G. Moraes[1], Vitor M. Anunciato[2], Glenn Obear[3], Frank Sexton[3], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]FCA/UNESP, Botucatu, Brazil, [3]Exacto, Inc, Sharon, WI (58)

ABSTRACT

During the application of herbicides, the deposition of the product on non-target areas should be avoided. Drift reduction technologies aim to eliminate small droplets reducing the movement of the pesticide to non-target organisms. Nozzle design, application pressure, orifice size, and constituents of the spray solution can increase spray droplet size and decrease drift. The addition of adjuvants can improve herbicide deposition, retention, absorption and may alter the physicochemical properties of the spray solution. The objective of this research was to assess the combinations of dicamba with several adjuvant concentrations on the influence on droplet size, density, viscosity, and surface tension. The studies were conducted at the Pesticide Application Technology Laboratory at the West Central Research and Extension Center of the University of Nebraska-Lincoln in North Platte, NE, in 2017. The treatments evaluated were dicamba (XtendiMax®,) at 560 g ae ha^{-1} applied in a mixture with four concentrations of an experimental polyacrylamide surfactant (0.1, 0.5, 1, and 5% v v^{-1}). The droplet spectra study had a completely randomized experimental design and it was conducted in a low-speed wind tunnel using a laser diffraction system for droplet size measurements. To determine spray droplet size, the solutions were sprayed through two pre-orificed, non-venturi nozzles (ER11004 and DR11004) at 434 kPa and 24 km hr^{-1}, calibrated to deliver 140 L ha^{-1}. Each nozzle was traversed through the laser three separate times to measure the entire spray plume providing three replications. The second study had also a completely randomized design with three replications for density and viscosity using a concentration meter. The third study had a completely randomized design as well with five replications for surface tension using an optical tensiometer. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test with the Tukey's adjustment ($\alpha = 0.05$). Increased adjuvant concentration resulted in increased droplet size for both nozzles with adjuvant concentrations up to 1% v v^{-1}. The reduction of percent fines (<150 µm) occurred with the addition of adjuvant in all concentrations. The drift potential reduction was greater when using DR11004 nozzle and adjuvant concentrations higher than 0.5% v v^{-1}. The density of the solution decreased when 5% v v^{-1} of adjuvant was used with dicamba whereas the opposite occurred with viscosity. The surface tension was not changed by the treatments. Viscosity is not a good predictor for drift reduction because even with the lower concentrations of the adjuvant, reduction in percent fines and relative span occurred and whereas droplet size increased. Correlation among droplet size and physicochemical properties was calculated Pearson correlation index using R software (GGally package) ($\alpha = 0.05$). Viscosity has a positive correlation with droplet size and surface tension. Viscosity has a negative correlation with relative span and percent fines. To move forward formulations and adjuvants, we need to be aware that there are complex interactions that exist between different liquid physical properties and they need to be thoroughly investigate to optimize pesticide applications.

†Influence of Adjuvants Associated with Glufosinate and Glyphosate Tank-Mixtures on Weed Control. Ely Anderson*[1], Jeffrey A. Golus[1], Bruno C. Vieira[1], Susan Sun[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Croda, Inc., Edison, NJ (59)

ABSTRACT

Glufosinate mixed with dicamba or 2,4-D could help with resistant weeds by giving us two modes of action in a given tank solution. The overall weed control of these herbicides in mixtures could be enhanced with the addition of an adjuvant. Adjuvants have been shown to be beneficial to herbicides in tank solution when looking at translocation, efficacy, and abortion. Research was conducted at the Pesticide Application Technology Lab in North Platte, Nebraska through The University of Nebraska-Lincoln to better understand the interactions between unformulated glufosinate mixtures with 2, 4-D (Enlist One) or dicamba (Xtendimax) alone and in combination with two proprietary anionic surfactant blends on common waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer), velvetleaf (*Abutilon theophrasti* Medik), and common lambsquarters (*Chenopodium album* L.). Weed species were grown to 15 – 20 cm tall then sprayed using an AI95015EVS nozzle at 140L ha^{-1} in a single nozzle spray chamber. Plants were evaluated at 7, 14, 21, and 28 days after treatment. At 28 days, above ground biomass was harvested and placed in a dryer (65 C) for seven days. Dry biomass data was recorded and analyzed using ANOVA and means were separated using $\alpha = 0.05$. Results indicate that adding either anionic surfactant to glufosinate resulted in greater overall weed control then having glufosinate alone. Adding an anionic surfactant to dicamba alone or glufosinate with dicamba on common lambsquarters showed an increase in overall control compared to both treatments alone. Across all species there was no statistical differences when observing 2,4-D alone with an anionic surfactant or 2,4-D in combination with glufosinate and an anionic surfactant. Overall, the addition of both anionic surfactants with glufosinate increased overall weed control.

Extraction Procedures for Polyurethane Foam (PUF) Samples for Dicamba Analysis. John A. Williams*, Tom Mueller; University of Tennessee, Knoxville, TN (60)

ABSTRACT

The three cornerstones for good trace analysis of pesticides are accuracy, precision and sensitivity. A variety of tools and methods are used to optimize the ability of researchers to find biologically relevant concentrations of components of interest in various matrixes. The recent deployment of dicamba tolerant crops and the resultant off target movement issues has necessitated the use of air samplers to collect dicamba samples under field and lab conditions. This report details our method validation and optimization to allow the use of PolyUrethane Foam (PUF) as a sampling media to collect dicamba and then later extract from the PUF and analyze using LC chromatography procedures. Caution is advised that apparent recoveries from freshly fortified samples may be more complete than is readily apparent. "Aged" samples that were fortified had less than perfect actual dicamba recoveries (< 50%). When neat solvents were used in concentration steps, dicamba movement within the lab equipment was minimal. When PUF extracts were fortified and then run through concentration steps, there appeared to be some dicamba movement and thus cross contamination of untreated, control samples. This cross contamination is well-known to many labs that have conducted dicamba research. Care should be taken to account for both the apparent low recovery of dicamba from actual PUF samples, which would understate true concentrations; and for cross carryover to some samples, which may overstate the true concentration (a false positive).

†Weed Wiper Utility in Dicamba Tolerant Soybean. Madison D. Kramer*[1], Travis R. Legleiter[2]; [1]University of Kentucky, Lynn, IN, [2]University of Kentucky, Princeton, KY (61)

ABSTRACT

Weed wiper technology has been traditionally used with glyphosate in conventional cropping systems. The introduction of glyphosate-resistant crops eliminated or limited the utility of weed wipers as broadcast applications were then possible to these crops. Although a new interest in weed wipers has arisen due to wide-spread herbicide resistance and the introduction of new herbicide tolerant crops. When reading the label of a dicamba herbicide the instructions for application using a weed wiper are conflicting and vague. An experiment was conducted in 2019 at a farm located in Princeton, Kentucky to evaluate and calculate how much spray solution is actually being applied to a dicamba-tolerant soybean system using a weed wiper and overall efficacy. A 1.5-m weed wiper was used to make applications with 1000 ml of a 1:1 solution of dicamba (BAPMA salt) and water. Two application methods were made which consisted of uni-directional and bi-directional passes for each application timing. For the uni-directional pass the wiper was wiped in a single direction and for the bi-directional pass the wiper was wiped in one direction and then wiped back in the reverse direction. Three application timings were analyzed in this experiment. The first timing was a post wiper application that contacted both the soybean foliage and *Amaranthus rudis* plants that existed within the soybean canopy. The second timing was the wiper contacting both the *Amaranthus rudis* plants and the soybean foliage following a pre-emergence herbicide application. The last timing mimicked an escape situation and was applied as a late post application when weeds were taller than the soybean canopy, following a pre-emergence and post broadcast application. After each pass the weed wiper was emptied, the amount of solution used was recorded, and refilled with 1000 ml. Weed wiper applications included as a component of an overall program resulted in 80% or greater control of *Amaranthus rudis.*Results from this study suggest control of *Amaranthus rudis* may increase using a bi-directional application. Calculations suggest that much higher amounts of dicamba are being applied on a per acre basis to a dicamba-tolerant soybean system when using weed wiper technology as compared to a broadcast application.

*Presenting Author

†Paper or poster in the graduate and/or undergraduate student contest

Posters: Extension

Getting Rid of Weeds Through Integrated Weed Management. Claudio G. Rubione*, Mark J. VanGessel; University of Delaware, Georgetown, DE (62)

ABSTRACT

Integrated weed management (IWM) combines various methods to reduce or eliminate the effect of weeds on crop production over time. These weed management methods form a "toolbox" in which "tools" can be integrated into a weed management plan catered to the particular farm and problem. The toolbox includes preventative, biological, chemical, cultural, and mechanical strategies. IWM also considers the weed species present and tailors strategies for these species.

In conventional crops, integrated weed management is not a replacement for herbicides. For many decades, herbicides have been the primary means of weed management due to their simplicity, effectiveness, and affordability. However, relying too much on a few herbicides has led to an increase of weed species that are not effectively controlled with the herbicide program or selecting for herbicide-resistant biotypes. IWM approaches go beyond relying on herbicide rotation and mixtures. IWM programs use all available methods that will best solve the problem.

To expand the use of IWM, GROW was developed as part of an USDA-ARS Area-Wide Project. GROW (Get Rid Of Weeds) is a place to find helpful, research-based resources for integrated weed management for herbicide-resistant weeds. GROW uses the website www.growiwm.org as a main source of information, as well as social media accounts (Tweeter, Instagram, YouTube and Facebook).

The website provides a resource for general interest content on IWM, current and ongoing research projects, and more in-depth information on specific management strategies. When navigating GROW's website users can either browse for general information such as "What is IWM? or "A-B-C's of IWM Principles" or go into more specific areas such as "IWM Toolbox" or "Resistant Weeds".

The website is currently undergoing a new design to improve the user experience. GROW is an opportunity for anyone working on IWM to have a platform to expand their reach and always looking for new partners.

The Habits of Private Applicators in Laundering Pesticide-Contaminated Clothing. Lizabeth A. Stahl*[1], Tana M. Haugen-Brown[2], Lisa M. Behnken[3], Ryan P. Miller[3], David A. Nicolai[4], Angie J. Peltier[5], Jared J. Goplen[6]; [1]University of Minnesota, Worthington, MN, [2]University of Minnesota Extension, Andover, MN, [3]University of Minnesota Extension, Rochester, MN, [4]University of Minnesota Extension, Farmington, MN, [5]University of Minnesota Extension, Crookston, MN, [6]University of Minnesota, Morris, MN (63)

ABSTRACT

In Minnesota, Certified Private Pesticide Applicators can renew their certification by attending a Private Pesticide Applicator recertification workshop every three years. At the start of most workshops, attendees are handed a Turning Technologies ResponseCard so attendees can respond to various questions throughout the program. ResponseCards are handed out randomly, which ensures anonymity of respondents. In 2019, recertification workshops included a module on the latest research and recommended best practices when laundering pesticide-contaminated work clothing. Attendees at 37 locations across Minnesota were asked questions about their own practices during this module. When asked what type of clothing they typically wore when working with pesticides (n=1,233), 45% replied they wore a long-sleeve shirt and pants, while 37% replied they wore whatever they happened to be wearing that day. Only 15% replied they wore what the pesticide label directed. When asked about how their clothing was laundered (n=1,273), 49% replied they laundered their clothing by themselves at home while 45% indicated someone else in their household laundered their clothing. When asked "Do you wash your pesticide clothing separately from other clothes", which is a recommended practice, 69% of respondents (n=1,415) replied "yes", 24% replied "no", and 7% replied "unsure". When asked if they rinsed the washer using a full cycle after doing a load of contaminated clothing (n=1,346), which is a recommended practice, 55% replied "no", while 30% replied "yes" and 15% "unsure". Additionally, attendees at 49 locations across the state were asked an evaluation question at the end of the workshop about their likelihood "to follow recommended laundering procedures for pesticide-contaminated clothing" as a result of attending the workshop. 97% of respondents (n=1,868) indicated they somewhat to strongly agreed that they would follow recommended laundering procedures for pesticide-contaminated clothing as a result of attending the workshop. These results indicate that the vast majority of farmers are not checking the label to see what they should be wearing when working with pesticides. Results also indicate a significant number of farmers may be placing themselves and their families at risk of pesticide exposure by not following recommended laundering procedures with pesticide-contaminated work clothing. However, results also indicate educational efforts can lead to changes in laundering procedures.

†Comparison of Spray Drift Models Predicted by AgDisp with Field Applications Using Air Inclusion Nozzles. Barbara Vukoja*, Guilherme S. Alves, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (64)

ABSTRACT

Droplet size distribution of a pesticide spray drift is recognized as a crucial factor affecting off-target movement. Introduction of air inclusion nozzles made it a lot easier for pesticide applicators to minimize drift. The venturi mechanism of pulling the air inside the nozzle body to make the droplets larger, hence the droplets are less prone to drift has changed pesticide applications in the last 30 years. Since off-target movement is important not just for the environment, but also for the human and animal health, greater attention devoted to evaluating and better understanding drift is needed. Regulatory authorities use models that can estimate spray drift potential under a variety of conditions and application methods. The one that the US EPA (Environmental Protection Agency) is using for estimating spray drift and deposition for its risk assessment is AGDISP (AGricultural DISPersal) model. AGDISP estimates downwind spray deposition using a number of parameters including nozzle type, drop size distribution, spray material properties and meteorological conditions. The objective of this study was to compare field data with AGDISP predictions. In this study, off-target movement was monitored during the application using PTSA (pyrene tetra sulfonic acid tetra sodium salt) dye as a tracer in a tank mixture with water. Application was made with 40 nozzles boom sprayer, with nozzles spaced 2.5 m apart and 0.6 m boom height. The tank solution was sprayed at 276 kPa and 8.6 km h^{-1} to deliver 140 L ha^{-1}. The study was conducted with twelve downwind distances and five nozzles ER11004, GA11004, AIXR11004, TDXL11004 and TTI11004. Mylar cards were set up for each distance to collect the drift deposition. Meteorological conditions (temperature, wind speed, wind direction and relative humidity) were also recorded during the application for the AGDISP drift predictions. The fluorescent dye was washed off of the collectors with pre-mixture of 91% isopropyl alcohol and water (1:10) and RFU (relative fluorescence unit) was measured with spectrometer. In order to simulate droplet size distribution (DSD) from the field, same five nozzles were used in the low-speed wind tunnel with Sympatec HELIOS VARIO/KR laser diffraction system, and DSD was used as a User-defined input in the AGDISP model. Results have shown that AgDisp model is underpredicting drift deposition for all nozzles and distances. Even though for the past several years a lot of work has been put in updating the model, more information is still missing in order to get credible predictions for ground application.

Evaluation of Preemergence Herbicides and Mechanical Incorporation on Cover Crop Establishment in V5 Corn. Ryan P. Miller*[1], Lizabeth A. Stahl[2], Jared J. Goplen[3], Lisa M. Behnken[1]; [1]University of Minnesota Extension, Rochester, MN, [2]University of Minnesota, Worthington, MN, [3]University of Minnesota, Morris, MN (65)

ABSTRACT

Field research was conducted at Rochester, MN in 2018 and 2019 to determine the influence of preemergence herbicides and incorporation on cover crop establishment in *Zea mays.* A split-plot randomized complete block design with four replications was used. Corn hybrid variety ‘DKC 51-38’ was planted on May 7, 2018 and corn hybrid variety ‘DKC 47-54’ was planted May 14, 2019. Corn was planted 2 inches deep in 30-inch rows at a rate of 32,000 seeds per acre. All herbicide applications were made at 4 MPH with a tractor-mounted sprayer delivering 15 GPA at 40 PSI using 110015 TTI nozzles. Treatments were made according to label instructions and adequate rainfall was received after each treatment. Preemergence treatments included: no preemergence herbicide; dimethenamide-P (Outlook) at 16 fl oz A^{-1}; saflufenacil (Sharpen) at 3 fl oz A^{-1}; dimethenamide-P and saflufenacil (Verdict) at 15 fl oz A^{-1}. All preemergence treatments were followed by a postemergence treatment of glyphosate (Roundup Powermax) at 32 fl oz A^{-1}. A cover crop blend consisting of *Secale cereale* (cereal rye) at 50 lb A^{-1} , *Brassica napus* (dwarf ‘Essex’ rape) at 6 lb A^{-1} , and *Trifolium alexandrinum* (berseem clover) at 8 lb A^{-1} was hand seeded into V5 corn 6 and 3 days after application (DAA) of the Roundup Powermax in 2018 and 2019, respectively. The main plot treatment was either incorporation or no incorporation of the cover crop seed with a Lilliston rolling cultivator. The Lilliston rolling cultivator was operated at 7 to 8 MPH and was set to cultivate soil away from the base of the corn stalk. Cover crop density was determined by counting plants in three 1.0 ft^2 quadrats per plot. In 2018 cover crop species varied in their response to cultivation and preemergence herbicide. Cereal rye establishment was not affected by cultivation or preemergence herbicide treatment while berseem clover establishment was greatest with cultivation, and preemergence herbicide effects were inconsistent. Dwarf ‘Essex’ rape establishment was better where cultivation was implemented and where either Outlook or no preemergence herbicide was used in 2018. In 2019, preemergence herbicide treatment did not affect cover crop establishment while cultivation increased establishment for all cover crop species. In 2018, cover crop densities declined during August and were almost nonexistent at the time of harvest. The exception was dwarf ‘Essex’ rape, which had a substantial number of surviving plants in the cultivated plots where no preemergence herbicide was applied. Dwarf ‘Essex’ rape, however, did not overwinter into spring 2019. In 2019, cover crop densities decreased after initial establishment, but substantial stands remained until harvest.

Wisconsin Waterhemp Management Challenge: Showcasing the Value and Efficacy of Several Preemergence Soybean Herbicides. Daniel H. Smith*, Ryan DeWerff, Maxwel C. Oliveira, Nicholas J. Arneson, Rodrigo Werle; University of Wisconsin-Madison, Madison, WI (66)

ABSTRACT

Waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer) is a troublesome weed species in soybean. Multiple site of action resistance, quick growth, and limited postemergence (POST) control options have resulted in increased reliance on preemergence (PRE) herbicides for waterhemp control. The objective of this study was to investigate the efficacy of commonly applied PRE soybean herbicides for waterhemp control. Soybean trials were established near Lancaster, WI (Silt loam soil, pH=7.3 and 2.4% OM; waterhemp was the predominant weed species) in the spring of 2018 and 2019 in a RCBD with four replications (3 x 7.6 m plot size). Soybeans were established on 24 May 2018 (variety: AG21X8) and 25 May 2019 (variety: AG21X7) at 385,000 seeds ha^{-1}. Prior to trial establishment, fields were in a corn-soybean crop rotation and were fall chisel-plowed and spring cultivated. Herbicide treatments consisted of single site of action (SOA) and multiple SOA premix combination products. Herbicide rates were based on soil characteristics and label requirements. Herbicides were applied within three days of planting with a CO_2 -pressurized backpack sprayer delivering 140 L ha^{-1} of spray solution using XR11002 flat-fan nozzles. No POST herbicides were applied to the study. At ~25 and 50 days after treatment (DAT) visual herbicide efficacy data were collected. At ~50 days after treatment, weed biomass was sampled and forced air dried at 60° C until constant dry weigh. ANOVA was performed with dry biomass (g) and waterhemp control (%), herbicide treatments and year were treated as fixed effects whereas replication was treated as random effect. Data were analyzed using R statistical software. All single SOA and multiple SOA combination herbicides except acetochlor, chlorimuron, cloransulam, imazethapyr, metribuzin + chlorimuron, provided > 90% control of waterhemp at 25 DAT. At 50 DAT, the following single SOA and multiple SOA combination herbicides provided >90% control: dimethenamid, flumioxazin, *S*-metolachlor, pyroxasulfone, flumioxazin + cloransulam, flumioxazin + pyroxasulfone, metribuzin + fomesafen, *S*-metolachlor + metribuzin, sulfentrazone + cloransulam, sulfentrazone + imazethapyr, sulfentrazone + metribuzin, chlorimuron + flumioxazin + pyroxasulfone, flumioxazin + chlorimuron, thifensulfuron, flumioxazin + pyroxasulfone + metribuzin, and saflufenacil + imazethapyr + pyroxasulfone. In 2018 and 2019 imazethapyr, cloransulam, chlorimuron, and metribuzin + chlorimuron did not reduce waterhemp dry biomass weight compared to control treatment. Additionally, in 2019, S-metolachlor (high rate), pyroxasulfone (high rate), flumiozaxin, dimethenamid (high rate), saflufenacil, sulfentrazone, and acetochlor (low and high rate) did not significantly reduce waterhemp dry biomass weight. In 2018 and 2019 several soybean herbicides applied PRE provided effective control of waterhemp past recommended POST herbicide treatment timings. Highest control efficacy, reflected in visual rating and biomass data, was achieved with combination of group 2, 14, and/or 15 herbicides sprayed at appropriate rates. This trial showcases the value and efficacy of several PRE soybean herbicides for waterhemp control.

†Distribution of Glyphosate, ALS-Inhibitor and PSII-Inhibitor-Resistant Waterhemp Populations in Wisconsin. Felipe de Andrade Faleco*, David Stoltenberg, Mark Renz, Rodrigo Werle; University of Wisconsin-Madison, Madison, WI (67)

ABSTRACT

Waterhemp (*Amaranthus tuberculatus*) has unique biological features allowing it to adapt to current cropping systems and rapidly evolve resistance to commonly used herbicides, justifying why the species has become one of the most challenging weeds to control in agricultural systems in the Midwest United States. In Wisconsin, researchers have confirmed waterhemp resistance to three SOAs: ALS-, EPSPS- and PPO-inhibitor herbicides. The objective of this research was to determine the distribution of glyphosate (EPSPS), imazethapyr (ALS) and atrazine (PSII)-resistant waterhemp populations in Wisconsin corn and soybean production systems. Seed samples were collected by stakeholders from 88 agricultural Wisconsin fields in the fall of 2018 and submitted to UW-Madison. Treatments consisted of glyphosate (0.864 kg ai ha^{-1} + 2.184 kg ha^{-1} AMS), imazethapyr (0.072 kg ai ha^{-1}+ 2.352 kg ha^{-1} AMS + 0.868 L ha^{-1} COC), atrazine (1.121 kg ai ha^{-1} + 1.17 L ha^{-1} COC) applied at 1x and 3x label rates, and a nontreated control. Treatments were applied when plants reached 5 to 10 cm in height using a single-nozzle research track spray chamber with AI9502EVS nozzle tips, calibrated to deliver 140 L ha^{-1} of spray solution. The study was conducted in a CRD with 8 replications per herbicide treatment and conducted twice. At 21 days after treatment (DAT) visual evaluation (VE) of plant growth was taken on a scale of 1 to 10 (1 representing a dead plant and 10 a completely healthy plant), and plant aboveground biomass harvested. For each population and treatment, the percent of treated plants with VE $\geq$ 7 (plants capable of reproducing) was calculated. In this experiment, waterhemp populations were considered resistant to each treatment if more than 50% of treated plants across both experimental runs had VE $\geq$ 7. According to our results, 95% and 70% of waterhemp populations screened were found to be resistant to 1x and 3x of glyphosate, respectively, and 98% and 93% were found to be resistant to 1x and 3x imazethapyr, respectively. Atrazine experiments are being finalized and results will be presented at the annual meeting in December of 2019. In conclusion, glyphosate and imazethapyr-resistant waterhemp populations are widespread across corn and soybean production areas of Wisconsin, requiring awareness and action from stakeholders to mitigate its detrimental impacts.

Posters: Herbicide Physiology & Molecular Biology

Limited Absorption and Translocation of ^{14}C-glyphosate in Glyphosate-Resistant *Conyza sumatrensis*. Amanda dos Santos Souza*[1], Jéssica Ferreira Lourenço Leal[1], Ana Claudia Langaro[1], Vanessa Takeshita[2], Valdemar Luiz Tornisielo[2], Leonardo Oliveira Medici[1], Todd A. Gaines[3], Camila Ferreira de Pinho[1]; [1]Federal Rural University of Rio de Janeiro, Rio de Janeiro, Brazil, [2]University of Sao Paulo, Sao Paulo, Brazil, [3]Colorado State University, Fort Collins, CO (68)

ABSTRACT

Conyza sumatrensis is a troublesome weed in various production systems in world, due in part to its ability to evolve multiple resistance to key herbicides including glyphosate. Evolution of resistance to glyphosate has been recorded in a large number of weed species, including *C. sumatrensis.* Several mechanisms have been proposed for glyphosate resistance, included reduced translocation and uptake. The objective of this study was to investigate the patterns of absorption and translocation of glyphosate in resistant and susceptible *C. sumatrensis* populations. Four-leaf plants were selected for treatment. Formulated glyphosate was applied at 720 g a.e. ha^{-1} using a single-nozzle, overhead track sprayer calibrated to deliver 150 L ha^{-1}. Each plant was treated with 2.76 kBq of ^{14}C labeled glyphosate using a microapplicator. Plants were harvested at 6, 12, 24, 48, and 72 h after treatment (HAT) and split into the following four parts: treated leaves, leaves above the treated leaves, leaves below the treated leaves, and roots. For better visualization of final position of radiolabeled herbicide, treated plants were exposed on X-ray film. Plant parts previously divided were oven-dried at 50ºC for 48 h, and combusted in a biological oxidizer. There was no statistical difference in ^{14}C-glyphosate absorption between resistant and susceptible biotypes. The total absorption was 17.3% and the same trend was observed in both curves. Translocated glyphosate amount from the treated leaf was reduced in resistant plants compared to susceptible. ^{14}C-glyphosate translocation increased as a function of time; approximately 1.8% and 0.98% of the product was translocated at 72 HAT in susceptible and resistant biotypes, respectively. The resistant biotype showed no significant translocation to other parts of the plant. The susceptible biotype showed increasing translocation as a function of time, with a higher percentage of the radiolabelled product in the lower leaves, showing translocation of the herbicide to other parts of the plant. These results suggest that for glyphosate the resistance mechanism in *C. sumatrensis* involves reduced translocation in this resistant biotype.

†Recurrent Selection with Isoxadifen Decreases Control of *Echinochloa crus-galli* with Fenoxaprop-p-ethyl. Carlos Alberto G. Rigon*[1], Luan Cutti[2], Christian Menegaz[2], Aldo Merotto Jr[2], Todd Gaines[1]; [1]Colorado State University, Fort Collins, CO, [2]Federal University of Rio Grande do Sul, Porto Alegre, Brazil (69)

ABSTRACT

Safeners are chemical compounds used to increase crop selectivity by activating detoxification genes. The mechanisms activated by these compounds are similar to those related to weed resistance caused by increased metabolism. The objective of this study was to investigate the effect of safener isoxadifen-ethyl associated with fenoxaprop-p-ethyl on the evolution of herbicide resistance in *Echinochloa crus-galli* (L.). The biotypes used were MOST (susceptible to fenoxaprop and imazethapyr) and CAMAQ (resistant to imazethapyr by enhanced metabolism). Initially, experiments were carried out to determine the herbicide maximum doses that provide plant survival to fenoxaprop-p-ethyl (FE) and fenoxaprop-p-ethyl + isoxadifen (FE+IS). After that, selection experiments were carried out by two generations through low doses application of the herbicide treatments described above. The plant material used in the next experiments was composed by parental line (G0), plants of second generation without selection by herbicide (G2 unselected) and plants of second generation selected with fenoxaprop-p-ethyl (G2FE) or with fenoxaprop-p-ethyl + isoxadifen (G2FE+IS). Dose-response curve experiments were performed with the herbicides used in the selections with the generations G0, G2 unselected, G2FE and G2FE+IS to evaluate the sensibility decrease. Expression analysis of nine cytochrome P450 genes (CYPs) and two glutathione-S-transferase (GST) genes were performed by RT-qPCR in G0, G2 unselected, G2FE and G2FE+IS plants before and 24 h after applications of herbicides. Plant survival of both biotypes increased in the G2 plants compared to G0 after application of FE at low doses and, mainly, after FE+IS application. The resistance factors (RF) of the G2FE plants in relation to G0 was 2.3 and 2.2 for the biotypes MOST and CAMAQ, respectively. The RF for G2FE+IS plants in comparison with G0 increased to 3.3 and 1.8 for the MOST and CAMAQ, respectively. Some gene were up regulated in the selected G2 plants either by FE or FE+IS in relation to G0 plants. The genes *CYP72A258* (3-fold change) and *CYP81A12* (5-fold change) were up regulated when the safener isoxadifen was used in the selections in the biotype MOST and CAMAQ, respectively. The genes *CYP71AK2* and *CYP81A14* resulted in higher expression than the G0 plants after selection with FE and FE+IS in CAMAQ biotype. The use of low doses of fenoxaprop with or without the safener isoxadifen increased barnyardgrass survival. The treatment fenoxaprop + isoxadifen increased the tolerance to this herbicide in the selected G2 plants in MOST biotype. The safener isoxadifen up regulated *CYP* genes due the recurrent selection that could play an important role in detoxifying the herbicide molecules. This is the first report that recurrent selection by safener can be involved in the increasing herbicide tolerance in weeds.

A Trio-Binning Approach to Genome Assembly: Obtaining Haploid Waterhemp and Smooth Pigweed Genomes. Darci Giacomini*[1], Jacob S. Montgomery[1], Bridgit Waithaka[2], Christa Lanz[2], Detlef Weigel[2], Patrick J. Tranel[1]; [1]University of Illinois, Urbana, IL, [3]Max Planck Institute of Developmental Biology, Tuebingen, Germany (70)

ABSTRACT

Genome assemblies from diploid or polyploid plants potentially contain many erroneous sequences due to misassembly or collapse of the parental alleles. This can have large impacts on some downstream analyses, including linkage analysis, functional studies, and population genetics, which require accurate allelic references. To generate haploid genome assemblies for waterhemp and smooth pigweed, hybrid offspring between the two species were first generated by crossing an ALS-inhibitor-resistant male waterhemp plant to an ALS-inhibitor-sensitive monoecious smooth pigweed plant. A pre-emergence screen using a 10x field rate of imazethapyr (0.7 kg ai ha^{-1}) selected putative hybrid plants and true hybrids were confirmed using an *ITS* assay. Genomic DNA from the parent plants and a male hybrid offspring were extracted and sequenced; both parents were sequenced to ~50x coverage using Illumina 150 bp reads and the hybrid was sequenced to >200x coverage using PacBio long-read technology. Following a trio-binning approach, the parental short reads were used to classify the hybrid long reads into two groups, one for each parent. This haplotype binning step successfully classified over 99.8% of the PacBio reads, with ~40.1% identified as coming from the smooth pigweed parent and ~59.7% from the waterhemp parent. Each group of reads was then separately error-corrected, trimmed, and assembled using Canu v1.8. This approach may be applied to other weed species that are capable of hybridizing to build two high-quality haploid genomes for the price of one.

†Antioxidant Enzyme Activity in Rapid-Response 2,4-D-Resistant *Conyza sumatrensis*. Jéssica Ferreira Lourenço Leal*[1], Amanda dos Santos Souza[1], Junior Borella[1], Ana Claudia Langaro[1], Todd A. Gaines[2], Aroldo Ferreira Lopes Machado[1], Camila Ferreira de Pinho[1]; [1]Federal Rural University of Rio de Janeiro, Rio de Janeiro, Brazil, [2]Colorado State University, Fort Collins, CO (71)

ABSTRACT

A 2,4-D resistant biotype of Sumatran fleabane (*Conyza sumatrensis*) from Brazil exhibits a differential-response to 2,4-D application. The main symptom of 2,4-D is necrosis in leaves within 30 min, with the re-establishment of the normal growth 1- to 2-weeks after 2,4-D treatment. Necrosis symptoms may be a result of an oxidative burst mediated by increase in reactive oxygen species (ROS). The aim of this work was to evaluate the short time-induced oxidative stress mediated necrosis and differential antioxidant enzyme activity to 2,4-D herbicide in 2,4-D-resistant and -susceptible *C. sumatrensis*. The experiment was arranged in a fully randomized design with four replicates. The assay was carried out to evaluate the rapid response induced by 2,4-D (1005 kg ha^{-1}) in resistant and susceptible biotypes of *C. sumatrensis* at 1, 4 and 8 h after application (HAA). The rapid response was evaluated by measuring the content of hydrogen peroxide (H_2O_2) and lipid peroxidation. In addition, the activity of the antioxidant enzymes superoxide dismutase (SOD), catalase (CAT), ascorbate peroxidase (APX), glutathione reductase (GR) and glutathione S-transferase (GST) were measured. The treatment effects were separated at $p \leq 0.05$ and adjusted using Fisher's Protected LSD. The H_2O_2 content accumulated in leaf tissue after 4h in 2,4-D-resistant biotype and 8 HAA in 2,4-D-susceptible biotype. At 4 HAA the 2,4-D-susceptible biotype showed an increase in lipid peroxidation and at 8 HAA accumulated H_2O_2. Basal antioxidant enzyme activities were different between resistant and susceptible biotypes. 2,4-D-resistant biotype increased antioxidant enzyme activities compared to the susceptible biotype, although the activities of all enzymes generally did not differ between untreated and treated 2,4-D resistant biotype at 1, 4 and 8 HAA. The CAT and SOD in the 2,4-D-susceptible biotype increased compared with the untreated one at 1 HAA and GST and GR declined in treated compared with the untreated at 8 HAA. The rapid response of the 2,4-D resistance biotype is due to increase in the H_2O_2 content while the basal antioxidant enzyme activity is higher in the resistant biotype.

Posters: Invasive Weeds, Rangeland, Pasture, and Vegetation Management

Comparison of Saflufenacil to Synthetic Auxins for Common Cocklebur and Common Ragweed Control in Cool-Season Grass Pastures. J.D. Green*, Eduardo Lago, Kendal Bowman; University of Kentucky, Lexington, KY (72)

ABSTRACT

Summer annual weeds such as common cocklebur (*Xanthium strumarium* L.) and common ragweed (*Ambrosia artemisiifolia* L.) limit livestock grazing in cool-season grass pastures. Herbicide application in midsummer with synthetic auxin based herbicides are often constrained by the presence of nearby susceptible crops and vegetation. Three field studies were conducted during 2018 and 2019 in Woodford, and 2019 in Owen County, Kentucky to evaluate saflufenacil (37 g ai ha^{-1}) and halosulfuron (52 g ai ha^{-1}) as non-synthetic auxin type herbicides for control of cocklebur and common ragweeds in grazed pastures. These treatments were compared to 2,4-D [choline salt] (1065 g ae ha^{-1}), premixtures of dicamba + 2,4-D (280 g ae ha^{-1} + 785 g ae ha^{-1}), aminopyralid + 2,4-D (86 g ae ha^{-1} + 700 g ae ha^{-1}), and triclopyr + fluroxypyr (420 g ae ha^{-1} + 125 g ae ha^{-1}). Treatments were evaluated at 30, 60 and 90 days after the application (DAA). Visual cocklebur control was 100% for all herbicide treatments 30 DAA at Woodford in 2018. At 60 DAA control remained at nearly 100% for all treatments, except for slightly less control observed with triclopyr + fluroxypry and halosulfuron. At 90 DAA herbicide treatments with saflufenacil, 2,4-D, dicamba + 2,4-D, and aminopyralid + 2,4-D continued to provide 100% control; whereas, triclopyr + fluroxypyr and halosulfuron gave 90 and 94% control, respectively. All herbicide treatments at Woodford in 2019 at 30, 60, and 90 DAA provided nearly 100% cocklebur control. Common ragweed control in Woodford during 2018 and 2019 at 30, 60, and 90 DAA was >95% with saflufenacil, dicamba + 2,4-D, and aminopyralid + 2,4-D. Less control was observed at 30 and 60 DAA with treatments of triclopyr + fluroxypyr, 2,4-D, and halosulfuron which ranged from 68 to 85% control. In Woodford 2018 at 90 DAA 93% common ragweed control was observed with 2,4-D and triclopyr + fluroxypyr; whereas, halosulfuron provided 80% control. At Woodford in 2019 halosulfuron, 2,4-D, and triclopyr + fluroxypyr provided from 83 to 88% control 90 DAA. At Owen in 2019 saflufenacil and aminopyralid + 2,4-D provided 100% common ragweed control 30 DAA; 2,4-D and dicamba + 2,4-D provided 88 and 98% control, respectively; and triclopyr + fluroxypyr was 80%. The halosulfuron treatment provided only 55% control. At 60 and 90 DAA all herbicide treatments provided >90% common ragweed control, except halosulfuron, provided less than 78% control. Differences in plant density measurements among herbicide treatments was similar to the visual control observed.

†Use of Acetic Acid for Spring Burndown of Select Annual Weeds. Emma L. Gaither*[1], H Vlieger[2], Shaun M. Billman[1], Timothy C. Rice[1], Reid J. Smeda[1]; [1]University of Missouri, Columbia, MO, [2]Vlieger Farm Supply, Inc., Maurice, IA (73)

ABSTRACT

Acetic acid is an effective non-selective, contact herbicide targeting weeds in organic production systems. Optimum activity depends upon uniform coverage on targeted species and appropriate adjuvants. Acetic acid was evaluated alone and in combination with a plant oil-based surfactant for efficacy on select annual weeds. A greenhouse experiment was conducted on wild mustard (*Sinapis arvensis* L.), common waterhemp (*Amaranthus rudis* Sauer), large crabgrass (*Digitaria sanguinalis* L. Scop.), common ragweed (*Ambrosia artemisiifolia* L.), common lambsquarters (*Chenopodium album* L.), velvetleaf (*Abutilon theophrasti* Medik.), horseweed (*Conyza canadensis* L. Cronq), and giant foxtail (*Setaria faberi* Herrm.) at sizes of 5-10 and 10-15 cm. Plants were treated with 2% acetic acid, 20% acetic acid, 1:1 v v^{-1} 2% acetic acid:surfactant, and 1:2 v/v 2% acetic acid:surfactant. At 1 day after treatment (DAT), up to 71% visual injury was observed on all species following application of acetic acid + surfactant. At 7 DAT acetic acid treatments containing surfactant resulted in 65-100% injury. For the 1:1 v v^{-1} acetic acid:surfactant treatment, monocots exhibited slightly greater mean injury (84%) than dicots (76%). The 1:2 acetic acid:surfactant treatment resulted in a high level of control across all weed species, with a mean visual injury of 93% at 7 DAT. Twenty percent acetic acid resulted in a mean injury of 73% at 7 DAT for common waterhemp, common ragweed, common lambsquarters, velvetleaf, wild mustard, and horseweed but was not as effective on large crabgrass and giant foxtail (44%). At 7 DAT, 2% acetic acid alone resulted in less than 2% visual injury. Results at 14 DAT were similar to those at 7 DAT. The performance of acetic acid + surfactant was similar for 5-10 versus 10-15 cm weeds. Overall, the addition of surfactant to acetic acid reduced weed biomass at 14 DAT by 69-76% compared to 2% acetic acid alone, and by 27-41% compared to 20% acetic acid alone. The plant oil-based surfactant added to 2% acetic acid resulted in similar efficacy on weed suppression as 20% acetic acid alone. Because weed control is a major limiting factor in organic production systems, post-directed acetic acid + surfactant can be an effective tool for weed management.

Effects of GF-3731 on Weed Control, Productivity and Clover Cover in Rotationally Grazed Grass-Clover Swards. Jose Luiz Carvalho de Souza Dias*[1], Mark Renz[1], Scott Flynn[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]Corteva AgriScience, Lees Summit, MO (74)

ABSTRACT

GF-3731 (florpyrauxifen-benzyl and 2,4-D) is a new product developed by Corteva Agriscience for broadleaf weed control in pastures with limited injury to select clover species. As little information is available on clover response under grazing pressure, efficacy on common pasture weeds and resulting yield, our objective was to evaluated these parameters in rotationally grazed cool-season grass-clover mixed swards. Experiments were conducted from May 2019 through September 2019 in two pastures located near Lancaster (LARS) and Prairie Du Sac (PDS) Wisconsin. Main forage grasses present at both locations included tall fescue (*Lolium arundinaceum* S.), orchard grass (*Dactylis glomerate* L.) and smooth brome (*Bromus inermis* L.). Both white clover (*Trifolium repens* L.) and red clover (*Trifolium pretense* L.) were equally present at LARS, while PDS was predominately white clover. GF-3731 was broadcasted at 1.75 L ha^{-1} (24 fl oz A^{-1}) with a tractor-mounted sprayer calibrated to deliver 187 L ha^{-1} after emergence of annual (LARS 6/1) or biennial (PDS 5/7) weeds and compared to an untreated control. This experiment was replicated four times in a randomized complete block design at both locations. Weed control and clover susceptibility was evaluated by percent cover and aboveground biomass prior each grazing. Response variables were separated into plant classes (clover, perennial grasses and broadleaf weeds) and subjected to ANOVA to test for herbicide, location, and their interaction effects. Results were pooled across locations due to a lack of treatment by location interaction. Means were separated with a Student's t-test ($\alpha = 0.05$) when appropriate. GF-3731 controlled broadleaf weeds at both sites as broadleaf weed cover was 3.6, 4.1 and 5.8-fold lower on GF-3731 treated pastures 30, 60 and 90 DAT, respectively. Similarly, GF-3731 provided 5.0-fold lower total season broadleaf biomass production (104 vs 518 kg DM ha^{-1} for GF-3731 and control, respectively). Clover cover was 18 and 17% lower on treated pastures at 30 and 60 DAT but was similar by 90 DAT. Likewise, clover biomass was three-fold greater on untreated pastures at 30 DAT but no differences were detected at 60 and 90 DAT. This resulted in lower total season clover biomass on GF-3731 treated pastures (729 kg DM ha^{-1}) compared to untreated pastures (1,282 kg DM ha^{-1}). In contrast, perennial forage grass cover was greater on GF-3731 treated pastures at 30 DAT, but no differences were detected 60 or 90 DAT in cover or total season perennial grass biomass. In conclusion, the use of GF-3731 appears to be a promising tool for broadleaf weed management in cool season grass-clover mixed swards in the Midwestern United States. Although clover suppression was observed on GF-3731, pastures maintained significant clover cover and biomass while reducing broadleaf weeds compared to untreated plots. Results also suggest clover tolerance to GF-3731 is species dependent as white and red clover exhibited different tolerance levels. Future research should investigate the susceptibility of different clover species to GF-3731 and management practices to limit injury of susceptible clovers.

Effect of Application Timing of Residual Herbicides on Waterhemp Control in Established Alfalfa. Jose Luiz Carvalho de Souza Dias*[1], Mark Renz[1], Roger Becker[2], Erin Burns[3], John Wallace[4]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Minnesota, Minneapolis, MN, [3]Michigan State University, East Lansing, MI, [4]Penn State, University Park, PA (75)

ABSTRACT

Dairy production systems in Wisconsin rely on alfalfa as a key component in their ration. However, these systems have recently been invaded by waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer), one of the most troublesome weed species in the Midwestern United States. Little is known about the impact and control of this species in established alfalfa. To address this issue we conducted an experiment in an established alfalfa field, in Omro, WI. Our objectives were to determine the impact of residual herbicides applied after the first or second harvest on waterhemp control, alfalfa yield and waterhemp's ability to produce viable seeds. Three residual herbicides evaluated were acetochlor at 1.7 kg ha^{-1}, flumioxazin at 140 g ha^{-1} and pendimethalin at 2.13 kg ha^{-1}. Theses herbicides were applied either after the first (6/3) or second (7/7) harvest. A sequential application of acetochlor at 1.7 kg ha^{-1} (after first cut) followed by flumioxazin at 140 g ha^{-1} (after second cut) was also included, resulting in 7 different herbicide treatments plus a control. Aboveground biomass (kg DM ha^{-1}) was estimated for the 2nd, 3rd, and 4th cut of the season and summed. Biomass data was separated into plant classes (alfalfa, waterhemp, other weeds) for statistical analyses. Data were subjected to ANOVA and means separated using Fisher's LSD test ($\alpha = 0.05$) when appropriate. Waterhemp seed production was visually assessed prior field cuts and after the 4th cut. Herbicide treatments had no impact on alfalfa biomass at any harvest interval or when summed across all three. While no waterhemp biomass was observed in the second cut, all treatments decreased waterhemp biomass during the third harvest. Acetochlor applied on 6/3 and flumioxazin applied on both timings provided ≥ 90% biomass reduction. At the fourth harvest, acetochlor (6/3) and the sequential application of acetochlor (6/3) followed by flumioxazin (7/7) were the only treatments that continued to provide >90% waterhemp biomass suppression as all herbicides applied on 7/7 provided ≤ 77% waterhemp suppression. The most effective treatments for total season waterhemp biomass production were acetochlor applied on 6/3 (94% reduction) and acetochlor + flumioxazin (94% reduction). These were followed by flumixazin and acetochlor (86 and 82% reduction, respectively) both applied on 7/7. Despite the herbicides and frequent harvests, waterhemp plants were able to produce viable seeds after the fourth harvest in all treatments (September). While alflalfa yields were not affected, reductions in forage quality may occur, especially in the 4th harvest, and require further research. Given waterhemp survival and reproduction occurred in successful herbicide treatments, integrated approaches such as PRE herbicides followed by effective POST herbicides will be required to assure weed seed bank reductions. Knoweldge of the resistance status of waterhemp populations will be critical in developing these strategies as few herbicide mode of actions exist that do not have resistant waterhemp populations in the United States. Additional research at different sites is needed to validate these findings.

Evaluation of Options for Dormant Stem Brush Control. Joseph Omielan*; University of Kentucky, Lexington, KY (76)

ABSTRACT

While mechanical (mowing) and chemical options are available during the growing season to manage woody vegetation, dormant-stem herbicide applications are another option outside the growing season that extend the spray season. A trial was established in an area of mixed brush regrowth near Nortonville KY to compare the efficacy of four treatments plus a control. They were applied on March 8, 2016 before bud break at 468 L ha^{-1} using a TeeJet® Boomless tip mounted on the rear of an ATV. Plots were 12 m long X 3.7 m wide and were arranged as a RCBD with 4 replications. The woody vegetation was 1.5 to 1.8 m high at application. The species in the plots included tulip poplar (*Liriodendron tulipifera* L.), sweet gum (*Liquidambar styraciflua* L.), winged elm (*Ulmus alata* Michx*.)*, smooth sumac (*Rhus glabra* L.), devil's walking stick (*Aralia spinosa* L.), and blackberry (*Rubus* L.).

All the herbicide mixes included basal oil @ 18.7 L ha^{-1} to help get the herbicide through the bark and surfactant @ 9.4 L ha^{-1} to emulsify the oil with the water carrier. The different treatments were as follows: Trt 1: BK800 @ 14 L ha^{-1} + Garlon 4 Ultra @ 4.7 L ha^{-1}; Trt 2: Garlon 4 Ultra @ 18.7 L ha^{-1} + Milestone @ 0.2 L ha^{-1}; Trt 3: Garlon 4 Ultra @ 9.4 L ha^{-1} + Viewpoint @ 840 g ha^{-1}; Trt 4: Patron 170 @ 8 L ha^{-1} + Garlon 4 Ultra @ 9.4 L ha^{-1} + Patriot @ 210 g ha^{-1}. The Garlon (triclopyr) does not have residual soil activity. The components with some soil activity were the dicamba in BK800 (Trt 1), aminopyralid in Milestone (Trt 2), aminocyclopyrachlor + imazapyr + metsulfuron in Viewpoint (Trt 3), and metsulfuron in Patriot (Trt 4).

The plots were rated visually 57 (5/3/2016), 72 (5/18/2016), 114 (6/29/2016), 205 (9/28/2016), and 422 (5/3/2017) days after treatment (DAT). The following spring at the 422 DAT rating, % herbaceous cover, % woody lower and upper canopy cover plus % woody stem leafout data were collected. Data were analyzed using ARM software and treatment means were compared using Fisher's LSD at p = 0.05.

The spray coverage or, rather, the lack of coverage was evident in the plots after leaf out. This illustrated the importance of good coverage for the most efficacious control results. All the treatments gave good initial results in brush suppression but many of the plants still leafed out from buds outside the spray pattern and continued to grow. Assessments the following season provided information on how many of these plants actually died and how efficacious the herbicide mixes. The treatment that stood out was Garlon + Milestone (Treatment 2) which had less lower canopy cover and woody stem leafout than control. Many of these stems were dead and dry. It can take time for treatment differences to become evident with perennials.

Posters: Weed Biology, Ecology, Management

†Determining Single or Multiple Origins of Glyphosate Resistant *Kochia scoparia* by Comparison of EPSPS Sequence Duplication Across Populations. Todd A. Gaines[1], Eric L. Patterson[2], Andrea Dixon[3], Crystal D. Sparks*[1], Karl Ravet[1], Philip Westra[1], Joel Felix[4], Don W. Morishita[5], Prashant Jha[6], Andrew Kniss[7]; [1]Colorado State University, Fort Collins, CO, [2]Michigan State University, East Lansing, MI, [3]Rothamsted Research, Harpenden, England, [4]Oregon State University, Ontario, OR, [5]University of Idaho, Kimberly, ID, [6]Iowa State University, Ames, IA, [7]University of Wyoming, Laramie, WY (77)

ABSTRACT

The first report of Glyphosate resistant kochia (*Bassia scoparia*) was from a Kansas location in 2007 and over the past decade incidences have been reported across the Great Plains, Intermountain West, Pacific Northwest, and Canadian Prairie provinces. To address whether resistance evolved once in kochia and spread, or if multiple independent origins of glyphosate resistance occurred over time, kochia was sampled from 45 locations in eight US states and 1 Canadian province. Initially, eleven polymorphic Simple Sequence Repeat (SSR) markers were developed from whole genome sequencing to compare different populations of glyphosate resistant kochia. The results showed high levels of diversity between the populations and attempts to find patterns of relatedness were inconclusive. A different approach was then taken by utilizing the assembled genomic region containing the EPSPS duplicatiom from a resistant population in Colorado (M32). The assembly in this population revealed at least two types of repetitive units of varying sizes, each containing EPSPS along with several other genes, and at least one type of transposable element-containing sequence inserted near the EPSPS genes. For this study these distinct sequence features were used as markers to compare populations of glyphosate resistant kochia from different regions. Population analysis revealed that northern Wyoming, Oregon/Idaho, and Canada lacked the distinct genetic elements shared by the southern Great Plains samples which contained the same EPSPS repeat structure and mobile genetic element characterized from the assembly. These results suggest glyphosate resistance in these spatially separated kochia populations could have evolved from separate independent events.

†Regional Differences in Kochia Germination from the US Great Plains: Effect of Water Potential and Temperature. Ramawatar Yadav*[1], Prashant Jha[2], Andrew Kniss[3], Nevin C. Lawrence[4], Gustavo Sbatella[5]; [1]Iowa State University, Ames, IA, [2]Iowa State University, Ames, IA, [3]University of Wyoming, Laramie, WY, [4]University of Nebraska-Lincoln, Lincoln, NE, [5]University of Wyoming, Powell, WY (78)

ABSTRACT

Development of glyphosate and ALS-resistant kochia [*Bassia scoparia* (L.) A. J. Scott] in the US Great Plains is a serious concern for producers, especially in sugar beet-based crop rotations due to a lack of alternative chemistries to control kochia in sugar beet. Therefore, there is an urgent need to implement ecological weed management strategies. This requires improved understanding of regional differences in kochia germination patterns (Objective 1) and using that information to design ecological strategies to deplete kochia seed banks (Objective 2). To fulfill objective 1, experiments (two runs) were conducted in 2018 at the MSU-SARC, Huntley, MT to quantify germination characteristics of 44 kochia accessions collected from northern (Huntley, MT; Powell, WY) and southern (Lingle, WY; Scottsbluff, NE) regions. Eight water potential treatments from 0 to –1.2 MPa and eight temperature treatments from 4 to 26 C were evaluated. An event-time, 3-parameter log-logistic model was used. A mixed-effects model was used to test treatment differences between northern and southern accessions. Results indicated that moisture requirements for kochia germination did not differ between northern and southern region, which implies that changes in moisture regimes may not explain differential kochia emergence patterns across the N-S transect. At optimal temperatures (15 to 26 C), thermal requirements for kochia germination did not differ between northern and southern regions. However, at sub-optimal temperatures (4 to 12 C), kochia from the northern region took less time to achieve 50% germination and had higher cumulative germination than kochia from the southern region. Therefore, a stale seed bed approach may be more effective in the southern region of the U.S. Great Plains to stimulate kochia germination early in the spring and exhaust the seed bank using tillage or non-selective herbicides prior to late-planted crops such as dry bean (planted in early June) grown in rotation with sugar beet (planted in mid-April).

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

Influence of Soil and Residue Management on Herbicide Carryover and Subsequent Crop Development. Kolby R. Grint*[1], Rodrigo Werle[1], Christopher Proctor[2], Nicholas J. Arneson[1], Maxwel C. Oliveira[1], Daniel H. Smith[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Nebraska-Lincoln, Lincoln, NE (79)

ABSTRACT

Application of herbicides with soil residual activity has become a standard recommendation for the management of troublesome weeds that have evolved resistance to commonly used postemergence herbicides in corn and soybean production systems. Carryover of residual herbicides can limit production of subsequent susceptible crops in rotation. In the fall of 2018, field experiments were established at two Wisconsin locations and one Nebraska location to investigate the potential of altering soil management practices to reduce herbicide carryover in cropping systems following corn or soybean in rotation. Treatments consisted of 3 soil management strategies (conventional tillage, no-till and a fall seeded cereal rye (*Secale cereale*) cover crop terminated two weeks prior to crop establishment) preceding either corn or soybeans (two separate studies), two herbicides (fomesafen and imazethapyr preceding corn, and mesotrione and clopyralid preceding soybean) and two herbicide rates (0.25 and 0.5X the full labeled rate of each product). A control treatment (no herbicide) for each soil management strategy was also included. Herbicides were sprayed in the fall prior to implementation of soil management strategies. Corn and soybeans were established in May of 2019. The study was conducted as a RCBD with 4 replicates. Soybean and corn canopy coverage seemed to be influenced mainly by soil management practices and not as a result of herbicide carryover. Soybean yield was significantly reduced at one Wisconsin location as a result of soil management with cover crops (p value: <0.05). Corn yield data are still being collected and results will be presented at the conference in December 2019. Excessive rainfall across sites and potential low herbicide rates (0.5 and 0.25X the label) adopted in this study may justify why no herbicide carryover impact was observed. Understanding the influence that soil management practices have on herbicide carryover can help growers optimize the usage of soil residual herbicides while minimizing potential impacts on subsequent crops and the environment. This research will be replicated in the 2019-2020 growing season.

†Management of Troublesome Weeds in XtendFlex® Soybean. Jesaelen G. Moraes*, Guilherme S. Alves, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (80)

ABSTRACT

XtendFlex® is the first technology with tolerance to dicamba, glyphosate and glufosinate herbicides giving farmers a more flexible weed control when managing tough-to-control and herbicide-resistant weeds. XtendFlex® soybean is expected to be released soon and it is very likely that these herbicides will be used in tank-mixtures alongside preemergent herbicides.It is likely a drift reducing agent (DRA) will be required for those applications. The objective of this research was to determine the expected control of troublesome weeds to tank-mixtures containing two or more herbicide sites-of-action as affected by DRAs. The study was conducted as a randomized complete block design in XtendFlex® soybean located in North Platte and Brule, NE. Two experimental runs were conducted. Spray treatments consisted of postemergence applications of glyphosate (1260 g ae ha^{-1}) and dicamba (560 g ae ha^{-1}) both alone and in combination and both herbicides in tank-mixture with glufosinate (656 ai ha^{-1}), clethodim (136 g ai ha^{-1}), clethodim plus glufosinate, clethodim plus acetochlor (1260 g ai ha^{-1}), or clethodim plus s-metolachlor (1067 g ai ha^{-1}). Tank-mixtures containing two or more herbicides were tested with two different drift reducing agents at 0.5 % v v^{-1}. A non-treated control was included. Each treatment was sprayed with a backpack sprayer calibrated to deliver 140 L ha^{-1} at 276 kPa and at 6.4 km hr^{-1} using the TTI11002 nozzle on a 50-cm nozzle spacing. Experimental plots consisted of four rows (three m wide) with 7.6 m in length replicated four times. Two rectangles (77 x 32 cm) were placed in each plot allowing visual estimations of herbicide injury in-row and between-row in addition to the entire plot. Data were collected at 7, 14, 21, and 28 days after application (DAA). At 28 DAA, the number of weeds in each rectangle was counted and harvested. Plants were placed in a dryer (60° C) until reaching a constant mass. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test with the Tukey adjustment. Spray solution by weed species interaction was significant at both locations. Antagonism was observed in specific treatments but tank-mixture performance was dependent on the herbicide (s) and DRA being used, weed species, and weed density. Tank-mixtures containing glufosinate significantly improved control of glyphosate-resistant populations. Results suggest that recommendations should be based on specific weed species to optimize spray application.

†Effective Herbicide Programs for Controlling 2,4-D-Resistant Palmer Amaranth in Enlist E3™ Soybeans. Isaac N. Effertz*[1], Vipan Kumar[2], J. Anita Dille[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS (81)

ABSTRACT

Evolution of 2,4-D-resistant Palmer amaranth (Amaranthus palmeri) is a potential threat to the newly developed stacked traits technology (resistance to glyphosate, 2,4-D and glufosinate) in soybean (also called Enlist E3™ soybean). A Palmer amaranth population (MHR) with resistance to 2,4-D and multiple resistance to glyphosate, chlorsulfuron, atrazine, and mesotrione was recently confirmed from southcentral Kansas. Field experiments were conducted at Kansas State University Agricultural Research Center Hays (KSU-ARCH) and on a grower's field near Great Bend, KS in 2019 to evaluate and develop effective alternative herbicide programs for controlling this MHR Palmer amaranth population in Enlist E3™ soybean. The Great Bend site was on a grower field from where a MHR Palmer amaranth population was originally identified. Seeds of that Palmer amaranth population were used at Hays. An Enlist E3™ soybean variety '5030017-02'was planted on June 4 in Great Bend and on June 5 in Hays. All experiments were conducted in a randomized complete block design with four replications. Fifteen different herbicide programs, including PRE alone and PRE followed by (fb) POST were tested. Data on percent visual control and density of Palmer amaranth were recorded on bi-weekly interval throughout the season. In addition, data on Palmer amaranth biomass and soybean grain yields were also assessed at crop maturity. Results indicated that PRE fb POST programs, including sulfentrazone + cloransulam-methyl fb glyphosate + 2,4-D choline + glufosinate, chlorimuron-ethyl + flumioxazin + metribuzin fb glyphosate + 2,4-D choline + glufosinate, sulfentrazone + metribuzin fb glyphosate + 2,4-D choline + glufosinate, sulfentrazone + pyroxasulfone fb glyphosate + 2,4-D choline + glufosinate, imazethapyr + metribuzin + flumioxazin fb glyphosate + 2,4-D choline + glufosinate, and chlorimuron-ethyl + flumioxazin + pyroxasulfone fb glyphosate + 2,4-D choline + glufosinate, provided 83 to 99% control and 82 to 99% biomass reductions of MHR Palmer amaranth population across both locations. These PRE fb POST programs provided at least 11% and 38% higher control compared to PRE alone programs at Hays and Great Bend, respectively. All herbicide programs improved soybean grain yield compared to non-treated weedy check plots; however, no differences were observed between PRE alone (one-pass) and PRE fb POST (two-pass programs). All PRE fb POST programs provided at least 44% more biomass reduction than PRE alone treatments in Great Bend. This was probably due to higher density of Palmer amaranth in Great Bend compared to Hays. These preliminary results indicate that PRE fb POST (two pass) programs tested in this research can proactively be utilized by the growers for effective season-long management of MHR Palmer amaranth in Enlist E3™ soybean.

Effect of Intercropping Winter Wheat with Soybean on Soybean Growth and Weed Control. Madison R. Decker*, Karla L. Gage, Ronald F. Krausz; Southern Illinois University-Carbondale, Carbondale, IL (82)

ABSTRACT

Common waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer) is among the most troublesome weeds for Midwestern soybean (*Glycine max* (L.) Merr.) producers due to the selection of biotypes resistant to multiple herbicide sites of action. As advances in herbicide discovery have declined, the need for innovative nonchemical weed control practices has increased. Therefore, field studies were conducted in 2019 at two locations to determine the effect of intercropping winter wheat in dicamba-resistant soybean on common waterhemp suppression and soybean development. Treatments included manipulations of winter wheat planting date, herbicide program, and termination date. Intercrop planting date and herbicide programs for the suppression of common waterhemp were evaluated at the Southern Illinois University Agronomy Research Center in Carbondale, Illinois. Winter wheat was planted on three different dates: prior to soybean planting in April, early-May, or at soybean planting in late-May. Herbicide applications included a preemergence (PRE) followed by (fb) a postemergence (POST) program, a POST-only program, hand-weed, and a nontreated comparison. The herbicide program consisted of fomesafen (333 g ai ha^{-1}) + s-metolachlor (1470 g ai ha^{-1}) or sulfentrazone (280 g ai ha^{-1}) + cloransulam (35 g ai ha^{-1}) and s-metolachlor (1506 g ai ha^{-1}) PRE, depending on field site, fb dicamba (560 g ai ha^{-1}) + glyphosate (1270 g ai ha^{-1}). Termination date and its impact on soybean development in a weed-free study was evaluated at the Southern Illinois University Belleville Research Center in Belleville, Illinois. Winter wheat and soybean were planted on the same date and the wheat intercrop was terminated at various soybean growth stages from vegetative stage V2 until V6. Common waterhemp suppression was similar in all intercropped treatments when compared to the standard soybean-only PRE fb POST program. Height was decreased in all intercropped plots when compared to soybean-only plots, but reduced height was not consistently associated with yield loss. Yield from the planting date study indicated that planting winter wheat concurrent with soybean planting resulted in no yield reduction compared to the standard soybean-only plots. Furthermore, results from the termination date study indicated no significant differences in yield among intercropped treatments terminated at V3 or sooner when compared to the standard soybean-only PRE fb POST program. Additionally, the soybean protein content was higher in all intercropped treatments when compared to the soybean-only PRE fb POST treatment. These data suggest that inter-seeding winter wheat in soybean in combination with an herbicide program could provide additional non-chemical integrated weed management for the suppression of common waterhemp. These studies will be repeated during the 2020 growing season to clarify these results.

†Tolerance of Two Horseweed Growth Types to Glyphosate. John A. Schramski*, Christy Sprague, Eric L. Patterson; Michigan State University, East Lansing, MI (83)

ABSTRACT

Increased adoption of reduced tillage practices and the spread of herbicide-resistant horseweed (*Erigeron canadensis* L.) continues to challenge Michigan farmers. Additionally, a recent shift from a winter-annual to a primarily summer-annual lifecycle, with emergence throughout the growing season, has required new management practices. Spring-emerging horseweed in Michigan does not form a typical rosette structure and immediately bolt upright to produce seed in the same growing season. Horseweed has been observed emerging simultaneously as "rosette" and "bolted" growth forms in the same field during mid to late summer. Additionally, potential differences in glyphosate sensitivity between the two growth forms has prompted questions related to the management and spread of herbicide-resistant horseweed. Can rosette and bolted growth forms occur from in seedlings from a single parent plant? Does growth form influence the glyphosate sensitivity? Experiments were conducted in 2019 to answer these questions. Horseweed seeds were collected from plants demonstrating the bolted form in fields throughout Michigan. Seeds were subjected to various biotic and abiotic stresses and the resulting growth form was determined. The stresses tested were temperature, photoperiod, shade, moisture, and intraspecies competition. Each effect resulted in all plants emerging as the rosette type for all populations. An additional study was conducted to test the effect of vernalization on growth form. Following vernalization, each population emerged as the bolted type. In conclusion, vernalization can influence the growth form of horseweed seedlings from the same parent plant. Additionally, dose response studies were conducted on both rosette and bolting forms in glyphosate-resistant and -susceptible populations to determine whether growth form influences glyphosate sensitivity. The experiment was a randomized complete block design with five replications and ten rates of glyphosate at a base rate of 1.3 kg ae ha^{-1} (0, 0.125x, 0.25x, 0.5x, 1x, 2x, 4x, 8x, 16x, and 32x). The different growth forms of horseweed may influence the efficacy of herbicide treatment and therefore control of this critical weed species. Work done to understand the environmental cues and eventually the genetics that influence horseweed growth form will be essential to continue our work controlling glyphosate-resistant horseweed.

†Response of Waterhemp Populations Collected from Five States to Dicamba and Glufosinate. Joe W. Ege*, Brian Dintelmann, William A. Tubbs, Eric G. Oseland, Mandy Bish, Kevin Bradley; University of Missouri, Columbia, MO (84)

ABSTRACT

Glufosinate and dicamba are commonly-used herbicides for post-emergent control of waterhemp (*Amaranthus tuberculatus*) in soybean. A greenhouse experiment was conducted in 2018 and 2019 to investigate the possibility of glufosinate or dicamba resistance in waterhemp populations from across several states. Waterhemp seedheads from 74 soybean fields in Illinois, Indiana, Louisiana, Missouri, and Nebraska, were collected prior to harvest. In greenhouse experiments, 0.15 g of seed from each population were planted in 27 x 54 cm trays, and germinated seedlings were thinned so that all plants were similar in height. Seedlings were maintained until average height was 10 cm, and then treated with one-half (1/2X) and full-use (1X) rates of glufosinate (328 g ai ha^{-1} and 656 g ai ha-^{1}, respectively) and dicamba (250 g ae ha^{-1} and 560 g ae ha^{-1}). Visual control ratings and percent plant survival were recorded for each population 21 days after application (21 DAA). Across all populations, the 1/2X rate of glufosinate resulted in 80% visual control and 27% plant survival while the 1X rate resulted in 91% visual control and 12% plant survival. At the 1/2X rate, dicamba provided 68% control and 31% survival while the 1X rate resulted in 86% control and 14% survival. Following full-use applications of glufosinate, over 10% of the waterhemp populations had plants that survived each biological and technical replication of the experiment. Similarly, over 16% of waterhemp populations had plants that survived the full-use rate of dicamba. Populations containing highest percentages of glufosinate and dicamba survivors will be subjected to more thorough dose-response analyses.

Genetics of Dioecy in Waterhemp and Palmer Amaranth: An Update. Jacob S. Montgomery*, Darci Giacomini, Patrick J. Tranel; University of Illinois, Urbana, IL (85)

ABSTRACT

With the frequency of herbicide-resistant weeds at an all-time high, production agriculture is feeling pressure to investigate weed management practices outside the field of chemical control. One such practice may be to manipulate sex ratios of dioecious weeds including waterhemp (*Amaranthus tuberculatus*) and Palmer amaranth (*A. palmeri*) to increase the likelihood of producing male progeny over female progeny. Before any gender-manipulation management practices may be developed, however, an understanding of the genetic basis of sex-determination is needed. To this end, a genome-wide association study was previously conducted on Palmer amaranth and waterhemp to identify genomic sequences linked to the male phenotype. This study produced molecular markers for maleness as well as a rough estimation of the sizes of the Y-chromosomal region in these two species. In the current study, these male molecular markers were aligned to male and female long-read genome assemblies of Palmer amaranth to identify the Y-chromosomal region. We identified one region of interest which was approximately the size of our previous estimate. This result offers a list of candidate genes for sex-determination in Palmer amaranth and confirms the viability of this approach. These data will help guide analysis of gene expression comparisons between male and female Palmer amaranth as well as Y-chromosomal region detection in waterhemp once a male assembly becomes available. In addition, better molecular markers were developed to more reliably test for maleness in Palmer amaranth and waterhemp. These markers will aid in isolating male and female plants in crossing experiments and in examining the lability of sex expression in these two species.

†Weed Control with Glufosinate Using Adjuvants. Estefania G. Polli*, Gabrielle de Castro Macedo, Bruno C. Vieira, Greg Kruger; University of Nebraska-Lincoln, North Platte, NE (86)

ABSTRACT

Glufosinate is a contact herbicide widely used for broadleaf and grass weeds control. The efficacy of this herbicide is variable among species and environmental conditions such as high temperatures and low relative humidity. In these conditions the herbicide droplet evaporation rate is higher which reduces the glufosinate uptake. New adjuvant technologies aiming to enhance droplet contact angle and humectancy could provide growers a very useful tool to improve the efficacy of glufosinate under unfavorable conditions. The objective of this study was to investigate the influence of adjuvants (surfactant + humectant) on the performance of two glufosinate formulations (Liberty 280-SL® and Interline®) on barnyardgrass (*Echinochloa crus-galli* (L.) P. Beauv.) and common lambsquarters (*Chenopodium album* L.). Plants were grown under greenhouse conditions at the Pesticide Application Technology Laboratory, West Central Research and Extension Center in North Platte, Nebraska between April and June of 2019. Plants (30- to 32-cm tall) were sprayed with a three nozzle track spray chamber calibrated to deliver 140 L ha^{-1} using TT11015 nozzles at 276 kPa. Applications were made using discriminant doses of glufosinate (328 g ai ha^{-1}), surfactant + humectant adjuvants (0.5 or 0.125% v v^{-1}) and AMS (1680 g ha^{-1}). The experiment was conducted in a completely randomized design with four replications. Visual estimations of injury were recorded at 7, 14, 21 and 28 days after treatment (DAT). At 28 DAT the surviving plants above-ground biomass were harvested and oven-dried at 65 C to constant weight. Biomass data were subjected to analysis of variance and treatment means were separated using Tukey's test ($\alpha = 0.05$). The results showed that the presence of surfactants and humectants on tank-mixture with Interline and AMS increased control by 17% and 48% for barnyardgrass and common lambsquarters, respectively. However, improvements on Liberty efficacy were not observed for either weed species. Further field studies investigating the performance of those adjuvants are necessary as glufosinate activity is highly variable on different weed species and under different environment conditions.

†Optimizing Respray Interval Using Only Glufosinate or Dicamba or 2,4-D for Control of Large Marestail or Waterhemp. Alexis L. Meadows*, Brent S. Heaton, Mark L. Bernards; Western Illinois University, Macomb, IL (87)

ABSTRACT

The optimal size to control waterhemp (*Amaranthus tuberculatus*) and marestail (horseweed) (*Conyza canadensis*) is before they reach 10 cm tall. However, herbicide application are frequently made to weeds larger than 10 cm because of unfavorable weather conditions, inadequate scouting or insufficient application resources. This results in weed escapes that compete for crop yield, add seeds to the seed bank, or hasten the evolution of herbicide resistance. Our objective of this study was to determine the optimal respray intervals for glufosinate, dicamba, or 2, 4-D on large waterhemp and marestail. Two field trials were conducted at the WIU Agronomy Farm during the 2019 growing season. Initial applications were made to 25 cm tall marestail and 20 cm tall waterhemp. Respray intervals were at 4, 7, 14, and 21 days after the initial application. Application rates of 654 g glufosinate-ammonium ha^{-1} , 560 g ae dicamba ha^{-1} , or 1060 g ae 2,4-D ha^{-1} were used for both initial and respray application. Weed control was visually estimated at 7, 14, 21 and 28 days.

Palmer Amaranth Adaptation to the Upper Midwest. Madison Melms*[1], Maxwel C. Oliveira[2], Mark L. Bernards[3], Amit J. Jhala[4], Chris Proctor[4], Strahinja Stepanovic[5], Rodrigo Werle[2]; [1]University of Wisconsin-Platteville, Platteville, WI, [2]University of Wisconsin-Madison, Madison, WI, [3]Western Illinois University, Macomb, IL, [4]University of Nebraska-Lincoln, Lincoln, NE, [5]University of Nebraska-Lincoln, Grant, NE (88)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri*) is ranked as the most troublesome weed species in the southern United States. In recent years, Palmer amaranth has become more predominant in the southern part of the Midwest United States, further increasing the complexity of weed management in corn and soybean production systems in the region. However, Palmer amaranth adaptation to the upper Midwestern states such as Wisconsin is uncertain. The objective of this study was to evaluate the adaptation of Palmer amaranth to different cropping systems (corn, soybeans and fallow) across a range of US Midwest climates. A Palmer amaranth population from Grant, Nebraska collected from a soybean field in the fall of 2017 was used as the source population for the study. The study was conducted in five locations: Grant, Clay Center, and Lincoln, Nebraska; Macomb, Illinois; and Arlington, Wisconsin, simulating southwest-to-northeast dissemination of the species during 2018 and 2019. At each location, a block of corn and soybean were planted in May following locally adopted practices and a fallow block established, all within the same field. Palmer amaranth plants were started under greenhouse conditions and transplanted to the field at the 2-3 leaf stage (5 to 8 cm in height) in all locations. To simulate early- and late-emerging cohorts, Palmer amaranth seedlings were transplanted at two timings, early June and early July to the soybean, corn, and fallow blocks. Twenty-four Palmer amaranth seedlings were equidistantly placed (0.76 m apart) between rows within each cropping system. Palmer amaranth plants were harvested at or after flowering (methodology varied across locations) and the gender and biomass (dry matter) of each individual plant recorded. Palmer amaranth gender and biomass were analyzed with chi-squared and ANOVA in R, respectively. Results across locations, transplanting time, and cropping-systems indicate that the gender ratio in Palmer amaranth did not deviate from the expected 50:50 (male:female) ratio ($P > 0.05$). Palmer amaranth produced higher biomass when growing in fallow for both June or July, except at Havelock, producing more biomass in July than June in Arlington and Grant. When growing in corn and soybeans, Palmer amaranth produced higher biomass when transplanted in June than July. For example, when transplanted in July and corn, Palmer amaranth produced < 4 g plant^{-1} in all locations but varied from 7.1 to 32.4 g plant^{-1} in June. Palmer amaranth growth was influenced by location, emergence time and crop canopy type. Palmer amaranth produced more biomass at the two westernmost Nebraska locations (Grant and Clay Center; center of origin of the population used herein) but it was also able to reach reproductive stages and produce a significant amount of biomass in the northernmost site, particularly when early transplanted and under fallow or less competitive crop canopy (soybean). Results of this study indicate that if seeds are introduced and proper management is not adopted immediately, Palmer amaranth will likely establish and thrive in the upper Midwest cropping systems.

†Influence of Grain Sorghum Planting Dates and Palmer Amaranth Emergence Timings on Competitive Outcomes. Lindsey Gastler*, J. Anita Dille; Kansas State University, Manhattan, KS (89)

ABSTRACT

In 2019, field experiments were conducted near Manhattan and Hutchinson, KS to determine the influence of grain sorghum (*Sorghum bicolor* L.) planting dates and Palmer amaranth (*Amaranthus palmeri* S. Wats.) emergence timings on competitive outcomes. The two planting dates for sorghum, approximately one month apart, were 6/3 and 7/1 at Manhattan and 5/17 and 6/17 at Hutchinson. Natural populations of Palmer amaranth were established at two emergence timings relative to crop planting along with a weed-free treatment. Palmer amaranth was thinned to a target population, individuals marked, and maintained throughout the season. Each week, measurements were recorded to track the growth of the sorghum and Palmer amaranth, and on biweekly basis, two grain sorghum and two Palmer amaranth plants were harvested to measure size characteristics. Grain sorghum yield was taken from 1.5 m by 4.5 m area in Manhattan and 1.5 m by 2 m area in Hutchinson. In Manhattan and Hutchinson, later planted sorghum grew faster than early planted sorghum when compared on a common time scale of days after planting (DAP). In Manhattan, Palmer amaranth emergence and establishment was poor in the early planted sorghum, possibly due to weather conditions. In the late-planted sorghum treatment in Manhattan and in both early- and late-planted sorghum treatments in Hutchinson, Palmer amaranth was shorter than grain sorghum up to sorghum boot stage, and then they exceeded sorghum height. In Manhattan, no difference in yield was observed between planting dates in weed-free treatments, while in Hutchinson, yield of early-planted sorghum was approximately half as much as late-planted sorghum due to poor crop establishment and poor crop pollination influenced by weather conditions. This study examined the various strategies that grain sorghum and Palmer amaranth use to compete in a system and provided a better understanding of how to reduce Palmer amaranth in grain sorghum.

†The Impacts of a Cereal Rye Cover Crop Planting Date, Seeding Rate and Herbicide Program on Management of Glyphosate-Resistant Horseweed in No-Till Soybeans. Alyssa Lamb*, Mark Loux, Alexander Lindsey, Anthony Dobbels; The Ohio State University, Columbus, OH (90)

ABSTRACT

Horseweed (*Conyza canadensis* L. Cronq.) is one of the most common and troublesome weeds in Ohio soybean (*Glycine max* L. Merr.) fields. Resistance to a number of herbicides greatly limits control options for this weed. Meanwhile, increased interest in conservation management has led to an increase in the number of acres that farmers are planting with cover crops and without tillage. Cereal rye (*Secale cereale* L.) is one of the most popular cover crops in Ohio and has weed suppressive characteristics. Two field studies were conducted from the fall of 2016 through the fall of 2018 to determine the effect of a rye cover crop planting date and seeding rate on control of glyphosate-resistant horseweed in soybeans, when integrated with fall-applied foliar herbicides or spring-applied residual herbicides. The rye was planted in late September and late October at seeding rates of 0, 50, and 100 kg ha^{-1}. Horseweed population density was unaffected by rye planting date both years in both studies. Horseweed density was generally greater in the absence of a rye cover crop compared with both seeding rates, with the exception of year two in the residual study where density was higher in the high seeding rate. In year one of the spring residual study, horseweed density was reduced at the highest level of residual, flumioxazin plus metribuzin, compared with flumioxazin alone or no residual. In the second year, both residual herbicide treatments reduced density compared with the nontreated. The fall herbicide treatment reduced horseweed density compared with the absence of a fall treatment in both years. Overall, these results suggest that cereal rye used as a cover crop before no-till soybeans has the potential to reduce glyphosate-resistant horseweed plant density, but that fall herbicide treatments and comprehensive spring residual programs are still important in ensuring effective horseweed control into the growing season.

Plant Community Response to Pasture Nutrient Management Strategies. Sarah Lancaster*, Phillip Lancaster, William McClain, Nicole Busdieker-Jesse; Missouri State University, Springfield, MO (91)

ABSTRACT

Grazing management practices that account for nutrients that enter the system as cattle supplementation have the potential to improve nitrogen use efficiency of fescue-based beef production, thereby reducing nitrogen losses to the environment and increasing economic returns. In addition, the botanical composition of fescue pastures may be altered by changes in grazing management, including nutrient management. Therefore, the objectives of this research were to determine the influence of N source on plant community composition in tall fescue pastures.

Experiments were established in tall fescue pastures during 2017 and 2018. Four treatments were replicated four times during each year: 1) 67 kg nitrogen ha-1; 2) 2% of initial body weight per head per day of supplemental feed; 3) nitrogen fertilizer and supplemental feed; 4) no fertilizer and no supplemental feed. Pastures were divided into 8 paddocks that were 0.05 ha or 0.13 ha, for pastures receiving feed or not receiving feed, respectively. Fertilizer applications were made in March each year of the study. Triclopyr + fluroxypyr was applied to all pastures during September 2016. All pastures were stocked with four mixed-breed calves in mid-April of each year. Cattle were allowed to graze until early July of each year.

Canopy cover for all species present was estimated using a modified Daubenmire scale with 7 cover classes after cattle grazing both years. Estimates were recorded from 1-m2 quadrats at 10 randomly selected locations within each pasture. Canopy cover data were subjected to analysis of variance using the mixed procedure in SAS. Species richness was determined using the rich package in R.

A total of 46 unique plants species were found in the pastures during the study. The plant species most frequently observed included tall fescue, Kentucky bluegrass, orchardgrass, dallisgrass, Carolina horsenettle, hophornbeam copperleaf, and woolly croton. Due to herbicide application prior to the study, data were not pooled over year. Total canopy cover was similar during both years, but the mean number of species observed was 3.2 and 5.3 in 2017 and 2018, respectively. During 2017, fed pastures produced less total canopy cover, which appeared to be associated with reduced tall fescue cover in those pastures. The number of species present in pastures was not affected by additions of feed or fertilizer during 2017. During 2018, greater total canopy cover was observed in pastures with nitrogen fertilizer (Figure 2). Canopy cover by all grasses was also greater in fertilized pastures, as was canopy cover by native grasses; but canopy cover by tall fescue and forb species was not affected by fertilizer inputs. Canopy cover by brush species was greater in fed pastures than nonfed pastures during 2018.

†Use of Glufosinate, Glyphosate and 2,4-D Combinations for Weed Management. Ana Clara Gomes*, Gabrielle de Castro Macedo, Bruno C. Vieira, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (92)

ABSTRACT

It has been reported that herbicide tank-mixtures can result in antagonistic herbicide interactions reducing weed control in some instances. The objective of this study was to evaluate the efficacy of 2,4-D, glyphosate, and glufosinate applied alone and in tank-mixture on Palmer amaranth (*Amaranthus palmeri*) and kochia (*Bassia scoparia*) using two different nozzles. A field study was conducted in the summer of 2019 at the West Central Research and Extension Center in North Platte, Nebraska. A randomized complete block design with two nozzles and 15 herbicide treatments was implemented. Each treatment had four replications and the study was conducted twice. The nozzles used were AIXR11002 and TTI11002. The herbicide treatments were 2,4-D alone (798 g ae ha^{-1}); 2,4-D + glyphosate (784 g ae ha^{-1} + 833 g ae ha^{-1}); glyphosate alone (1,120 g ae ha^{-1}); glufosinate alone (654 g ai ha^{-1}); 2,4-D + glufosinate (798 g ae ha^{-1} + 654 g ai ha^{-1}); 2,4-D + glyphosate + glufosinate (784 g ae ha^{-1} + 833 g ae ha^{-1} + 654 g ai ha^{-1}); and glyphosate + glufosinate (1,120 g ae ha^{-1} + 654 g ai ha^{-1}). Solutions contained ammonium sulfate 5% v v^{-1}. Treatments were applied using a six-nozzle backpack sprayer at 276 kPa calibrated to deliver 140 L ha^{-1}. Plots were sprayed at two different timings. Visual estimations of injury were recorded at 21 days after treatment (DAT). Data were subjected to analysis of varianceand comparisons among treatments were performed using Fisher's least significant difference procedure at $\alpha = 0.05$. Herbicide solution influenced weed control for both species ($p < 0.0001$), whereas nozzle type did not influence Palmer amaranth ($p = 0.68$) or kochia control ($p = 0.87$). Overall, solutions containing 2,4-D had better control on Palmer amaranth as the population had glyphosate-resistant biotypes. For kochia, glufosinate alone, glufosinate + 2,4-D, and glufosinate + glyphosate provided satisfactory control (>75%). Overall, the glyphosate, 2,4-D, and glufosinate tank-mixture solution did not perform as expected, suggesting possible antagonistic interactions, especially on kochia. Additional studies are necessary to understand herbicide tank-mixture interactions for controlling herbicide-resistant weeds.

†Predicting *Amaranthus palmeri E*mergence with Thermal Time Models. Theresa A. Reinhardt Piskackova*, S. Chris Reberg-Horton, Robert J. Richardson, Katherine M. Jennings, Ramon G. Leon; North Carolina State University, Raleigh, NC (93)

ABSTRACT

Amaranthus palmeri S. Watson (Palmer amaranth) is a troublesome weed of the southeast United States and parts of the midwest. Highly competitive and a prolific seed producer, this weed has been difficult to manage. As it becomes more important to control this weed without the use of glyphosate, timing for weed removal is crucial. Predicting emergence is just the first step for approaching integrated weed management. The objectives of this study were to 1) characterize the pattern of Palmer amaranth emergence in North Carolina and 2) create a model for predicting Palmer amaranth emergence based on chronological, thermal, and hydrothermal time.

Palmer amaranth emergence was observed for 4 site years in North Carolina. Emergence began in May with a sharp increase and eventually reached a plateau, suggesting a sigmoidal pattern for modeling. A subset of collected emergence data was used to fit a several sigmoidal models over chronological, thermal, and hydrothermal time. A Gompertz model fit best and thermal time was the best predictor for the validation data. While there have been many reports of Palmer amaranth emergence from March to October, the data confirms that only a small percentage of Palmer amaranth emergence occurred after July.

Horseweed Rosette Survival Over the Winter. Erin Haramoto*[1], Ryan J. Collins[1], J. Anita Dille[2], Karla L. Gage[3], Reid J. Smeda[4], Brent Sunderlage[3]; [1]University of Kentucky, Lexington, KY, [2]Kansas State University, Manhattan, KS, [3]Southern Illinois University-Carbondale, Carbondale, IL, [4]University of Missouri, Columbia, MO (94)

ABSTRACT

Horseweed (*Erigeron canadensis*) can emerge in the fall or in the spring, particularly across mid latitude states like Kentucky, Illinois, Missouri, and Kansas. Since this species is easier to control when small, variability in emergence time makes its management more complex. Germination and emergence timing may be linked to edaphic and weather conditions in any given year – soil temperature above 12C, light quantity and quality, and adequate soil moisture have been indicated as important factors influencing marestail germination. Plants emerging in the fall may succumb to frost-heaving over the winter. Previous research from Indiana indicated that smaller plants (< 60 mm diameter) were more likely to survive the winter, while research from Ohio indicated the opposite – larger plants (> 40 mm) were more likely to survive. These contradictory findings suggest that specific weather and soil conditions, as well as soil properties, may determine the over-wintering success of this species.

Individual rosettes approximately 10-90 mm in diameter (100-200 per location) were flagged in different mid-latitude states in December 2018. Initial rosette diameter was measured, and plants were measured again in March or April 2019. In some locations, survival to the following spring was greater for larger plants. In Kentucky, for example, 90% of plants with initial diameter of 45-75 mm survived while no plants < 15 mm survived. In other locations, however, survival was not related to initial size. In Illinois, for example, 30-40% of plants survived regardless of their initial size. These findings suggest that specific soil conditions related to soil type and weather likely influence over-wintering success.

†Waterhemp Seed Production from Plants Damaged by Dicamba in a Soybean Field. Faith M. Duke*, Brent S. Heaton, Mark L. Bernards; Western Illinois University, Macomb, IL (95)

ABSTRACT

Greenhouse research showed no difference in waterhemp (*Amaranthus tuberculatus*) seed production from plants that survived increasing doses of dicamba up to 560 g ha^{-1}. We hypothesized that the uniformity of seed production may have been due to the restricted root zone of plants growing in 0.7 L pots and the lack of competition from a crop allowing severely injured plants adequate time to recover and reproduce. Our objective was to measure waterhemp seed production as affected by increasing dicamba dose from plants transplanted into a soybean (*Glycine max*) field at either the V1 or V8 growth stages. Two experiments were conducted in 2019 at the WIU Agronomy Farm. Soybeans were planted 14 June 2019 in 76 cm rows. Glyphosate-resistant waterhemp seed was planted in potting mix and plants were grown in the WIU Ag Greenhouse. When plants reached heights of 10- 20 cm (Experiment 1) or 10-40 cm tall (Experiment 2), they were treated with increasing dicamba doses (Experiment 1: 0, 18, 70, 140, 280, 560 g ae ha^{-1}; Experiment 2: 0, 37, 140, 280, 560, 1120 g ha^{-1}). They remained in the greenhouse for 11 days after treatment, and were then transplanted into the middle of the soybean rows (Experiment 1 was transplanted July 1; Experiment 2 was transplanted Aug 1). Waterhemp was rated for injury (0 = no injury, 100 = plant death) four weeks after treatment, for gender at flowering, and after senescence plants were harvested. Seed was threshed, weighed, and seed counts were estimated based on weight. Waterhemp injury increased with dicamba dose. At a dose of 560 g ha^{-1} the average injury at in Experiment 1 was 60%, but in Experiment 2, it was 85%, indicating decreased survival when plants were injured by dicamba in a taller soybean canopy.

†Impact of Cover Crops on Early Season Weed Control and Nitrogen Availability in Corn. Malynda M. O'Day*, J. Anita Dille, Kraig Roozeboom; Kansas State University, Manhattan, KS (96)

ABSTRACT

Cover crops are a valuable tool for weed suppression in an integrated weed management approach, however, implementation of cereal cover crops in corn is challenging due to soil N removal by a grass species prior to corn establishment. In 2019 a field study was implemented at the Kansas State University Ashland Bottoms Research Station near Manhattan, KS to determine the influence of cover crops on Palmer amaranth (*Amaranthus palmeri* S. Watson*)* suppression, corn (*Zea mays* L.) establishment, and impacts of removal or addition of N on corn yield. The experimental design was a randomized complete block with split-split plot arrangement with four replications and 3 levels: 4 cover crop treatments, two termination timings, and two N rates. Cover crop treatments were triticale (*x Triticosecale)* (101 kg ha^{-1}), pea (*Pisum sativum* L*.)* (73 kg ha^{-1}), triticale + pea, and a no cover crop control (NCC), with triticale drilled in November 2018 and peas drilled in April 2019. Cover crops were terminated 3 weeks prior to planting (3WPP) and at planting (TAP). Two nitrogen application rates were 168 and 101 kg ha^{-1} in order to quantify the impact of any N depletion on corn yield by the cover crops. Corn was planted on 6/6/2019at 64,250 seed ha^{-1}. Palmer amaranth density was recorded two weeks after the 3WPP termination timing. Palmer amaranth density and corn yield data were subjected to ANOVA at 5% level of significance and analyzed using LS Means with SAS once differences were observed. The pea treatment had little Palmer amaranth suppression regardless of termination timing and was not different from NCC. Greatest Palmer amaranth suppression occurred with triticale cover crops regardless of termination timing. Nitrogen fertilization level did not impact corn yield. However, corn yield differed between cover treatments with a 13 and 24% yield reduction in triticale and mixed treatments, respectively, compared to NCC and peas. Corn yield with the pea cover crop was not different than NCC. These findings suggest that a triticale cover crop can be used to provide Palmer amaranth suppression in corn. However, corn yield can be limited due to N fertilizer depletion by the grass cover crop. Future work should examine effects of different grass and legume cover crop species on available N levels and their effect on corn yield with the goal of creating a weed management strategy that can incorporate triticale without damaging corn yield.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

†Weed Control from Dicamba plus Glufosinate as Affected by Drift-reducing Adjuvants and Carrier Volume. Arthur F. Teodoro Duarte*, Guilherme S. Alves, Bruno C. Vieira, Kasey P. Schroeder, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (97)

ABSTRACT

Drift-reducing adjuvants have been commonly used in dicamba applications. They work by increasing droplet size, but may decrease efficacy of herbicides used in tank-mixtures with dicamba depending on the carrier volume and nozzle type. The objective of this study was to evaluate weed control from dicamba plus glufosinate in tank mixtures with different drift-reducing adjuvants using two carrier volumes and two nozzle types. A greenhouse experiment was conducted in a randomized complete block design with six replications in a 6 x 2 x 2 split-split-plot arrangement (solution x carrier volume x nozzle type). Herbicide solution (HS) was composed of dicamba plus glufosinate in tank mixtures using 1/3 of their label rates (186 g ae ha^{-1} and 218 g ai ha^{-1}, respectively). The adjuvants used were polyethoxylated hydroxyl aliphatics (PEHA), polyethylene glycol (PEG), polyvinyl polymer (PVP), surfactant blend (SB), and sodium polycarbox (SPC) at labeled rates of 0.25, 0.5, 0.5, 0.5, and 0.625% v v^{-1}, respectively. An additional solution with no adjuvants in the tank mixture was also tested. Applications were made using a three-nozzle spray chamber with 51-cm nozzle spacing and calibrated to deliver 140 and 187 L ha^{-1} through TTI11004 or ULD12004 nozzles at 276 kPa. The boom height was set at 51 cm above plants. Commom waterhemp (*Amaranthus rudis* J. D. Sauer) and kochia [*Bassia scoparia* (L.) A. J. Scott] were sprayed on plants at the three-leaf growth stage (approximately 13-cm tall). Plant aboveground was harvested at 21 days after treatment (DAT) and dry weight was recorded and converted into biomass reduction. The droplet size produced by each combination of solution, carrier volume, and nozzle type was measured using a laser diffraction system. The TTI produced coarser droplets than ULD across solutions. At 140 L ha^{-1}, all adjuvants, except PEHA, increased the droplet size in at least 123 µm compared to HS alone for both nozzle types. No interaction between factors was observed for biomass reduction on common waterhemp. An interaction between adjuvant and nozzle was observed for kochia. For common waterhemp, applications made through TTI and ULD nozzles resulted in similar biomass reduction (94%). The SPC adjuvant had less biomass reduction (93%) than the PEHA adjuvant (97%). No difference was observed between those adjuvants and the HS itself. Similarly, PEG, PVP, and SB adjuvants produced similar biomass reduction and did not differ from HS alone. By adding PEHA adjuvant to the HS, 17% more biomass reduction of kochia was observed using TTI compared with ULD nozzle, but no difference was obtained for the other solutions. Greater biomass reduction of kochia was observed using the SPC compared with PVP and SB sprayed through TTI nozzle. The PEHA produced less biomass reduction compared to other adjuvants when sprayed through the ULD nozzle. Results suggest that control of common waterhemp and kochia was not affected by reducing the carrier volume in dicamba plus glufosinate applications and drift-reducing adjuvants had influence on weed control depending on the weed species and nozzle type. Further research needs to be conducted to evaluate more nozzle types and weed species.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

Weed Species Diversity in Railroad Right-of-Ways. Andrew Osburn*, Mark Loux, Kent Harrison, Emilie Regnier; The Ohio State University, Columbus, OH (98)

ABSTRACT

A multiple phase study was conducted from 2018 to 2019 at a total of ten railroad crossing rights-of-way. The goal of this research was to gain a better understanding of weed species found in railroad crossing rights-of-way with the specific objectives: (1) determine the effect of intensity of herbicide use on plant species diversity at railroad crossings; (2) determine the difference in plant species diversity between urban and rural railroad crossings along one continuous central Ohio rail corridor; and (3) characterize the plant populations present in the seedbank for their response to glyphosate (site 9) and other herbicide sites of action. There was no difference in weed species diversity between intense and moderate management zone seedbanks based on Shannon's Index (H') = 1.36 vs 1.54. Urban sites had significantly greater diversity, H' = 1.64, than rural sites, H' = 1.26. Application of glyphosate at 1.7 kg ae ha^{-1} controlled most species that grew in soil samples, with some exceptions, notably horseweed and waterhemp. The progeny of the glyphosate-tolerant horseweed population was resistant to glyphosate (site 9) and to cloransulam-methyl (site 2), while being susceptible to atrazine (site 5). The progeny of the glyphosate-tolerant waterhemp population was resistant to glyphosate, while being susceptible to atrazine and fomesfen (site 14). These findings further demonstrate the importance of understanding how human activity and industrial herbicide applications shape plant communities and the implication that has on industrial, non-crop environments.

†Cocklebur Emergence Under Cereal Rye Residue Before and After Residual Herbicide Application. Wyatt S. Petersen*, William G. Johnson; Purdue University, West Lafayette, IN (99)

ABSTRACT

From 2012 to 2017, cover crop acreage rose 79 percent in Midwest agriculture. Weed suppression is one of the primary goals of many growers implementing cover crops into integrated weed management systems. Cover crops may achieve weed suppression through a variety of mechanisms, including soil shading, nutrient sequestration, allelopathy, and physical suppression. The current paradigm surrounding cover crop weed suppression is that all weeds are suppressed to varying degrees. Common cocklebur (*Xanthium strumarium*) is a common Midwest broadleaf weed. It is capable of germinating both on the soil surface and of depth of up to 15 cm, but is more likely to germinate when buried below the soil surface. This is due to increased soil moisture, lower temperature amplitudes, and the absence of light. Field trials in 2018 showed that pre-corn harvest cocklebur biomass and density were 10-fold higher in plots with large cereal rye biomass, compared to treatments with no cover crop or early-terminated cereal rye biomass. For this reason, field trials were conducted in 2019 to evaluate factors contributing to increased cocklebur vigor under a high-biomass cereal rye cover crop residue. A residual herbicide premix of atrazine, bicyclopyrone, mesotrione, and S-metolachlor was applied to half of all cover-cropped plots and fallow plots. All plots were kept weed free, and emerged common cocklebur was counted in each plot every one to two weeks. Soil volumetric water content (VWC) was continuously measured from June 26 to August 27 using soil moisture probes. Soil cores were taken from each plot to assess atrazine concentrations 45 days after herbicide application. Soil VWC was consistently 8 to 10 percent higher underneath cereal rye residue than in fallow soils. Atrazine concentrations were similar in both cover crop and fallow treatments. Underneath cereal rye residue, peak cocklebur germination was delayed by 2 weeks, and overall germination was prolonged by approximately one month compared to fallow soil. These results suggest that high-biomass cereal rye residue helps maintain optimal conditions for cocklebur germination through increased soil moisture and shading.

†Comparative Emergence and Growth of *Amaranthus tuberculatus* and *A. palmeri* in Iowa. Rebecca S. Baker*, Bob Hartzler; Iowa State University, Ames, IA (100)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri* S. Watson) and waterhemp (*Amaranthus tuberculatus* [Moq.] J. D. Sauer) are closely related, but their competitive abilities and native ranges differ greatly, with *A. palmeri* being more competitive in regions where the two species coexist. *A. palmeri* was first identified in Iowa in 2013, and since then has been introduced across the state. Objectives of this project are to compare the emergence, growth, and competitive abilities of *A. palmeri* and *A. tuberculatus* in Iowa. It is hypothesized that *A. palmeri* will emerge later than *A. tuberculatus* and be less competitive since *A. tuberculatus* is well-adapted to Iowa's climate and soil. Experiments included an *A. tuberculatus* population from central Iowa and two biotypes of *A. palmeri*, one from western Iowa and one from northeastern Kansas. An emergence study was established in the fall of 2018 by mixing seed within the upper 0.5 cm of soil, and seedling emergence was recorded throughout the 2019 growing season. Emergence of both species appeared to coincide with precipitation events. *A. tuberculatus* reached 90% emergence 25 days after initial emergence, compared to 48 days for *A. palmeri*. A common garden study was used to compare growth on two soil types, one moderately to poorly drained, typical of Iowa agricultural fields, and a well-drained soil more characteristic of the native range of *A. palmeri*. *A. palmeri* was 18% taller, 34% wider, and accumulated 85% more biomass than *A. tuberculatus* at both locations, with both species performing better on the well-drained soil. A replacement series compared the competitive abilities of *A. tuberculatus* and the western Iowa biotype of *A. palmeri*. Five planting densities were used: 100% *A. palmeri*, 100% *A. tuberculatus*, 75% *A. palmeri* / 25% *A. tuberculatus*, 75% *A. tuberculatus* / 25% *A. palmeri*, and 50/50. 36 plants were arranged in 6 rows of 6 with 5 cm spacing. *A. tuberculatus* was 21% taller and accumulated 48% more biomass than *A. palmeri* in all densities. Under non-competitive conditions, *A. palmeri* accumulated greater biomass than *A. tuberculatus*, but under competitive situations the inverse relationship was observed, suggesting that *A. palmeri* is poorly adapted to Iowa's environment at this time.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

If You Were a Waterhemp Plant, Where Would You Rather Be? Crop Canopy as an Effective SOA. Nikola Arsenijevic*, Ryan DeWerff, Nicholas J. Arneson, Maxwel C. Oliveira, Rodrigo Werle; University of Wisconsin-Madison, Madison, WI (101)

ABSTRACT

Waterhemp (*Amaranthus tuberculatus* Moq.) is a problematic weed species in cropping systems throughout Wisconsin and much of the North Central region. Early season weed control is crucial in order to minimize competition with crop and ultimately prevent yield loss. Waterhemp has evolved resistance to multiple herbicide SOA, thus becoming more difficult to control through chemical-based weed management programs. This has led to increased interest in the role of cultural practices as a means for weed control. The objective of this study was to evaluate the impact of soybean and corn crop canopy on suppression of waterhemp growth and development. A field experiment was conducted at Arlington Ag Research Station, Wisconsin in 2019. Treatments consisted of narrow (0.38 m) and wide (0.76 m) row soybean row spacing, corn (0.76 m), and fallow. The experiment was conducted in a RDBD (4 replicates) Starting at 24 days after crop planting, waterhemp seedlings from a Wisconsin population grown in the greenhouse were transplanted at the 2-3 true leaves growth stage in the study area at 10-day increments 5 different times with August 2nd representing the last transplanting time. Seedlings were transplanted between rows (2 and 3) for wide soybeans and corn, and row 3 and 4 for narrow soybeans. Waterhemp plants were harvested for biomass when they reached the flowering stage. Date of flowering, plant height, and gender data were recorded. The later the waterhemp was transplanted, the less biomass it was able to produce. Preliminary results indicate that corn, narrow and wide-rowed soybeans crop canopy equally and significantly reduced waterhemp biomass when compared to the fallow treatment. Preliminary results indicate the value of canopy for reducing waterhemp growth and the importance of adopting strategies to delay the emergence of this troublesome weed species (e.g., by using an effective pre-emergence herbicide program). The data of this research shows potential in emphasizing the importance and the role of crop canopy itself in suppression of troublesome weeds in soybean cropping systems. This study will be replicated in 2020.

†Sequential Application of Dimethenamid-p for Control of *Amaranthus palmeri* in Dry Bean. Nevin C. Lawrence[1], Amit J. Jhala[2], Joshua W. Miranda*[2]; [1]University of Nebraska-Lincoln, Scottsbluff, NE, [2]University of Nebraska-Lincoln, Lincoln (102)

ABSTRACT

Amaranthus palmeri S. Watson, is an emerging and troublesome weed species in western Nebraska characterized by season-long emergence, fast growth, high seed production, and resistance to many herbicide modes of action. Effective PRE and PPI herbicide programs are available to control *Amaranthus palmeri* in dry bean, however, due to widespread ALS-resistant biotypes fomesafen is the only effective POST herbicide labeled in dry edible bean in Nebraska. Strict in crop uses guidelines and crop rotation restrictions limit the use of fomesafen in western, Nebraska, and alternative options are needed to control *Amaranthus palmeri* after residual PRE and PPI options are no longer providing control. Dimethenamid-p is currently the only Group 15 herbicide registered for split PRE/POST applications in dry bean in Nebraska. A study was conducted in 2019 at the Panhandle Research & Extension Center in Scottsbluff, NE to evaluate the efficacy and ideal timing of dimethenamid-p as a split PRE/POST to control *Amaranthus palmeri* in dry bean. The pinto dry bean variety La Paz was planted on June 15th using a population of 210,000 p ha^{-1}. All treatments included a PRE application of pendimethalin (905 g ai ha^{-1}) + dimethenamid-p (422 g ai ha^{-1}). POST treatments included a nontreated check; imazamox (35 g ai ha^{-1}) + bentazon (674 g ai ha^{-1}) + fomesafen (281 g ai ha^{-1}); imazamox (35 g ai ha^{-1}) + bentazon (674 g ai ha^{-1}) + fomesafen (281 g ai ha^{-1}) + dimethenamid-p (422 g ai ha^{-1}); and dimethenamid-p (422 g ai ha^{-1}) all applied at V1 and V3 growth stages. V1 applications were made on July 1st and V3 applications on July 10th. Treatments were replicated four times and arranged within a randomized complete block design. Weed density and control ratings were taken on July 10th, August 10th, and September 4th. *Amaranthus palmeri* biomass was taken at the end of the season in September, where plants were dried for one week at 26°C after collection. Crop yield was not taken due to three damaging hail events which occurred in mid-August. Dimethenamid-p applied alone at V3 resulted in poor, 64%, control of *Amaranthus palmeri*, while dimethenamid-p applied alone at V1 and all other treatments including a pesticide provided greater than 95% control. *Amaranthus palmeri* density recorded in August was reflective of the control estimates with dimethenamid-p applied alone at V3 resulting in higher weed densities than dimethenamid-p applied alone at V1. *A. palmeri* biomass was not different among treatments, likely due to late season flushes occurring as a result of reduced dry bean stand following mid-August hail storms. Dimethenamid-p applied alone at V1 as part of a PRE/POST split program provides similar levels of *Amaranthus palmeri* as programs including fomesafen POST.

†Physical and Allelopathic Weed Suppression by Cover Crops. Darian Decker*, Sarah Lancaster; Missouri State University, Springfield, MO (103)

ABSTRACT

As herbicide resistance becomes more problematic to farmers, a multifaceted approach is necessary to combat the resistant weeds. This experiment compared waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer) and large crabgrass (*Digitaria sanguinalis* (L.) Scop.) suppression by three cover crop mixtures. Mixtures included: cereal rye (*Secale cereale* L.), cereal rye and Austrian winter pea (*Pisum savtivum* L.), and cereal rye, Austrian winter pea, and oilseed radish (*Raphanus sativus* L.). Each mixture was applied in three treatments; leachate of allelochemicals from cover crop residue, fresh residue, and dried, leached residue. The aim of these treatments was to determine whether physical suppression or allelopathy plays a greater role in weed suppression by cover crops. Cover crop residues had more impact on large crabgrass growth than waterhemp growth. In general, residue type influenced large crabgrass growth more than cover crop species. Fresh residue reduced the number of large crabgrass plants as well as photosynthetic activity while leachate increased large crabgrass biomass and leaf area. This implies that physical suppression plays a key role in suppressing weeds.

Germination Characteristics of 2,4-D-Resistant and –Susceptible Palmer Amaranth Under Varying Temperature Conditions. Rui Liu*, Vipan Kumar, Phillip W. Stahlman; Kansas State University, Hays, KS (104)

ABSTRACT

Occurrence of 2, 4-D resistance in Palmer amaranth is a potential threat to recently developed stacked traits crop technologies, including Enlist™ crops. To predict the evolution and further spread of 2,4-D resistance and develop effective management tactics for controlling 2,4-D-resistant Palmer amaranth populations, it is critical to understand the seed germination characteristics of 2,4-D-resistant and -susceptible Palmer amaranth populations. In this study, two 2,4-D- resistant (R1 and R2), and one 2,4-D-susceptible (S) Palmer amaranth populations collected from wheat-summer crop-fallow rotations in southcentral Kansas were investigated. Seeds obtained from R1 and R2 Palmer amaranth plants that survived 2, 4-D at 870 g ha^{-1} and grown under pollen isolated conditions in a greenhouse study in 2017 were used. All seeds were stored at room temperature until used. The objective of this study was to compare the germination characteristics of R1, R2, and S populations at constant (15, 20, 25, 30, 35, 40 C) and alternating (12 h high/12 h low) temperatures of 15/10, 20/15, 25/20, 30/25, 35/30, 40/35 C. A laboratory study was conducted at Kansas State University Agricultural Research Center-Hays (KSU-ARCH) in completely randomized design, with 4 replications. Fifty randomly selected seeds from each population were placed on filter paper in petri dish (9 -cm diam) and moistened with 5 ml of deionized water. Germination experiments were initiated by placing petri dishes in incubators set with aforementioned temperature regimes. All incubators were set at 12 h light/12 h dark cycle for all constant and alternating temperatures tested. The number of germinated seedlings were counted on alternate day for 14 days. The non-germinated seeds after 14 days of incubation were evaluated for viability using 1% tetrazolium solution. Cumulative germination of each population was calculated based on the percentage of total viable seeds. Data were subjected to analysis of variance (ANOVA) using PROC MIXED in SAS 9.3 and means were separated using Fisher's protected LSD test ($P < 0.05$). Results indicated that the total cumulative germination of R1 population did not differ from S at all constant temperatures, except 35C. In contrast, R2 population had significantly lower cumulative germination (52 to 65%) compared to S (75 to100%) population at constant temperatures of 20, 25, 30, and 35C. The cumulative germination of R2 was significantly lower (55 to 64%) than S (88 to 99%) under alternating temperatures of 30/25, 35/30, and 40/35C; whereas, the cumulative germination of R1 and S populations did not differ at all alternating temperatures tested. These preliminary results suggest that seeds from 2, 4-D resistant Palmer amaranth population (R2) are expected to be more persistent in the soil seed bank relative to the S population. Diversified weed control practices, including competitive crop rotations, spring/summer-planted cover crops in conjunction with strategic tillage and effective soil-residual herbicides would be needed to deplete the seedbank of this population.

†Hybridization Between *Amaranthus tuberculatus* and *A. arenicola*. Brent P. Murphy*, Patrick J. Tranel; University of Illinois, Urbana, IL (105)

ABSTRACT

Amaranthus arenicola (I. M. Johnst.) is native to the central and southwestern great plains. A dioecious plant, the species is frequently associated with sandy and arid regions, though it has been observed in agricultural fields. In contrast, *Amaranthus tuberculatus* (Moq.) Sauer is primarily observed within the Midwest, both west and east of the Mississippi river, and is generally associated with wet areas. Phylogenetic analysis places *A. arenicola* as a close relative to *A. tuberculatus*. While habitat preferences between the two species significantly diverge, the proximal genetic relationship suggests gene flow between the species is possible. This gene flow could result in the exchange of adaptive traits, which could facilitating the expansion of *A. tuberculatus* to a wider geography. Controlled crosses were conducted to determine the potential for gene flow between *A. arenicola* and *A. tuberculatus*. No significant differences in seed production was observed between inter and intra-specific crosses. Contrary to crosses between *A. tuberculatus* and monoecious amaranths, no changes in fecundity were observed within the F1 generation. These results suggests close compatibility between the species. Analysis of gene flow, as assayed through the exchange of herbicide resistance traits, is ongoing.

†Influence of Glufosinate and Dicamba in Tank-Mixtures on Weed Control. Pedro H. Alves Correa*[1], Gabrielle de Castro Macedo[1], Jesaelen G. Moraes[1], Vitor M. Anunciato[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]FCA/UNESP, Botucatu, Brazil (106)

ABSTRACT

Glufosinate and dicamba will be likely to be used in combination, alongside glyphosate, to broaden weed control. However, how those herbicides interact as affected by their rates have not been investigated thoroughly. The objective of this study was to find the most synergistic combination of glyphosate tank mixtures when using dicamba and glufosinate. A greenhouse study was conducted as a completely randomized design at the Pesticide Application Technology Laboratory in North Platte, NE on the following weed species: Palmer amaranth (*Amaranthus palmeri* S. Watson), velvetleaf (*Abutilon theophrasti* Medik.), green foxtail [*Setaria viridis* (L.) P. Beauv.], and kochia [*Bassia scoparia* (L.) A. J. Scott]. Herbicide treatments consisted of POST applications of six rates of glufosinate (0, 37, 74, 148, 295, and 590 g ai ha^{-1}) and six rates of dicamba (0, 35, 70, 140, 280, and 560 g ae ha^{-1}) sprayed alone and in all combinations. Each treatment was applied at 2.9 km hr^{-1} and 206 kPa to deliver 140 L ha^{-1} using a single-nozzle laboratory track sprayer equipped with an AI95015E nozzle. Two experimental runs were conducted and plants were sprayed at 15-cm tall and 20- to 25-cm tall during the first and second run, respectively. Visual estimations of herbicide injury were collected at 7, 14, 21, and 28 days after application (DAA). At 28 DAA, plants were clipped at the soil surface and placed in a dryer (60 C) until reaching a constant mass. Data were analyzed with a log-logistic model using the *drc* package in R software (R Foundation for Statistical Computing, Vienna, Austria). For velvetleaf, glufosinate (590 g ai ha^{-1}) in combination with 70, 140, 280, and 560 g ae ha^{-1} of dicamba provided a higher control than other treatments, with no significant differences among these treatments. Great control (>85%) of Palmer amaranth was observed regardless of the treatment, with the exclusion of glufosinate in its lower rates (74 and 37 g ai ha^{-1}) in absence of dicamba which led to plant regrowth. As dicamba has no activity in grasses, all treatments containing 140 g ai ha^{-1} of glufosinate or more provided a desired control (>85%) of green foxtail. For kochia, the better control (>80%) was observed when using 560 g ae ha^{-1} tank-mixed with 74, 140, 295, and 590 g ai ha^{-1} of glufosinate, with no difference between these treatments. Glufosinate at 295 or 590 g ai ha^{-1} by itself or in tank-mixture with any rate of dicamba provided >70% of control. According to the results, each species responds to the herbides differently, and the minimum rate of glufosinate to achieve a good control (>80%) for all of them was is 590 g ai ha^{-1} while for dicamba it may vary depending on the broadleaf species.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

Papers: Equipment and Application Methods

High Voltage Electricity for Weed Control. Thomas J. Peters*, Richard Zollinger; North Dakota State University, Fargo, ND (112)

ABSTRACT

Postemergence control of waterhemp (*Amaranthus tuberculatus* (Moq.) J.D. Sauer) has become our most important weed management challenge due to glyphosate (SOA 9) and ALS inhibitor (SOA 2) tolerant biotypes in sugarbeet production fields in Minnesota and North Dakota. Producers use ethofumesate, S-metolachlor, or ethofumesate plus S-metolachlor PRE followed by acetochlor, dimethenamid-P, or S-metolachlor POST for waterhemp control. Eighty-six percent of surveyed growers attending the 2019 winter grower seminars indicated good or excellent waterhemp control using layered soil residual herbicides. Growers have limited options for postemergence control of waterhemp escapes on certain acres every season. Electrical discharge systems (EDS) might represent a POST weed control option in low growing crops including sugarbeet and soybean. EDS kills weeds using electricity traveling through a copper bar rupturing vascular bundles on contact with main and secondary branches of target plants. Damage occurs when cellular fluids in the liquid phase are rapidly heated by electricity to the vapor phase. Target plants wilt after contact and tissue very rapidly dries and becomes brown. Electrical generating equipment (9-17 kV, 50 kW) was mounted at the rear of a tractor and driven by the power takeoff shaft. Plants varied in their tolerance to electricity depending on species, density, and operator ground speed. Repeat passes with EDS improved weed control and resultant sugarbeet root yield, presumably due to control of multiple species of weeds at different stages of growth in fields. Summary from experiments conducted from 1979 to 1981 was: a) EDS was most active on young, actively growing weeds, b) EDS controlled weeds with a dominant main branch, such as giant ragweed and sunflower, better than highly branched weeds, such as kochia or grasses; c) control was better on scattered than dense weed populations; d) a minimum of two passes or reduced tractor speeds was recommended for dense weed populations and e) damp to wet operating conditions favored weed control as compared to dry conditions and; f) EDS window of operation was narrow due to crop and weed development and environmental conditions. The second-generation EDS features improved generating equipment (24 kV, 200 kW), front mounted bar operation, and greater operator safety features compared to the original EDS design. Preliminary evaluation indicates repeat application on 7- to 10-day intervals provides control of waterhemp escapes at multiple growth stages in sugarbeet and soybean at 7.4 km h^{-1}. Waterhemp and common lambsquarters control with EDS was greater than giant ragweed control. EDS in sugarbeet production is not a stand-alone weed management treatment but a POST control treatment following layered soil residual herbicides to control weed escapes.

†Use of Pulse Width Modulation to Compare Carrier Volume and Dose Response on Soybean. Raquel B. Moreira*[1], Bruno C. Vieira[1], Benjamin P. Sperry[2], Dan Reynolds[3], Jeffrey A. Golus[1], Karina Beneton[1], Ulisses R. Antuniassi[4], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Florida, Gainesville, FL, [3]Mississippi State University, Starkville, MS, [4]UNESP, Sao Paulo, Brazil (113)

ABSTRACT

A major concern associated with the introduction of herbicide-resistant crops is the potential for herbicide drift. Drift simulation studies are usually performed with low herbicide rates applied at constant carrier volumes. However, these simulations differ from real herbicide drift events in terms of concentration of the pesticide in the droplet, droplet size and deposition pattern. Furthermore, it has been reported in the literature that carrier volume and consequently herbicide concentration within droplets can influence herbicide activity. The objective of this study was to compare soybean (non-dicamba-tolerant) injury and plant height reduction following applications of growth regulator herbicides at diminishing and constant carrier volumes. Field dose response studies were conducted in two experimental runs with a factorial treatment arrangement with three herbicides, five doses, and two solution concentrations as factors in a randomized complete block design with four replications. Soybean plants (R1) were sprayed with five herbicide rates (1, 1/4, 1/8, 1/16, and 1/64), in which dicamba, 2,4-D, and florpyrauxifen 1X rates corresponded to 0.56, 2.22, and 0.0295 kg ae ha^{-1}, respectively. Applications were performed using TT11002 nozzles at 276 kPa with fixed carrier volumes at 187 L ha^{-1} (diluted), and variable carrier volumes (concentrated) proportionally reduced with the herbicide rate using a pulse-width modulation system (PWM) at different duty cycles. Plant height (28 DAT) and visual estimations of injury (21 DAT) were recorded following treatment applications. Plant height and injury data were analyzed using a four-parameter log logistic model with the drc package in R. Herbicide solution concentration influenced plant height reduction for dicamba ($p = 0.0002$), 2,4-D ($p = 0.0603$), and florpyrauxifen ($p < 0.0001$). Generally, diluted herbicide solutions resulted in more plant growth reduction compared to concentrated solutions. For visual estimations of injury, applications with diluted and concentrated solutions had similar injury for 2,4-D ($p = 0.8077$) and dicamba ($p = 0.7882$). This indicates that using conventional methods to determine injury from drift are probably sufficient, but having concentrated applications are necessary for drift predictions with florpyrauxifen. Future work will investigate the impact of these two application methods on yield.

Evaluation of Air Induction Spray Nozzle Compatibility with Pulse-Width Modulation Nozzle Control Systems. Nick J. Fleitz*[1], Brian Finstrom[2]; [1]Pentair Hypro, New Brighton, MN, [2]Capstan, Topeka, KS (114)

ABSTRACT

Pulse-width modulation (PWM) nozzle control systems have become increasingly commonplace in North American crop production. These systems provide many established benefits to applicators in the form of consistent droplet size, reduced drift potential and improved application accuracy through turn compensation. Historically, application industry nozzle recommendations for pulse-width modulation have cautioned against the use of air induction nozzles and instead promoted the use of pre-orifice and flat fan nozzle technology. Recent shifts in these recommendations have resulted in air induction spray nozzles being promoted and paired with PWM nozzle control systems. To test the compatibility of air induction spray nozzles with PWM systems droplet size was measured using a Malvern Spray Tec droplet analyzer equipped with a Capstan EVO PWM nozzle control system. Air induction spray nozzles were tested under PWM spraying conditions. Duty cycles of 25, 50, 75, 90 and 100% were tested for their effect on Dv10, Dv50, Dv90, % droplets <141um and relative span. Production of % droplets <141um progressively increased as duty cycle decreased from 100 to 25%. Treatments applied at 25% duty cycle resulted in the greatest increase of fine droplet production. Duty cycle changes were observed to have minimal impact on relative span across all nozzles. Visual observations indicated a loss in spray droplet distribution uniformity caused by increasing concentrations of spray droplets directly under air induction nozzles.

†Herbicide Efficacy as Influenced by Nozzle for UAV Applications. Trenton Houston*[1], W. C. Hoffmann[2], Jeffrey A. Golus[1], Bruno C. Vieira[1], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Prology Consulting, College Station, TX (115)

ABSTRACT

sUAVs (small unmanned aerial vehicle) are currently being used primarily as a scouting tool with the integration of remote sensing. The use of sUAVs to apply pesticides with precision at low labor costs may be possible. sUAV applications are dependent on low volume applications to make the system efficient and plausible in modern agricultural systems. This application depends on selecting the right nozzle by herbicide combination to achieve optimum efficacy levels. Currently, there are not any pesticides that are labeled for application using a UAV platform in U.S. Guidelines for herbicide applications, including pressures ranges, nozzles, nozzle arrangement, boom height, application speed and carrier volume to maximize efficacy are scarce and fragmented. The objective of this study was to identify nozzle by herbicide combinations that would optimize a UAV application and how the nozzle by herbicide combinations affect efficacy at different carrier volumes. This research was conducted at the Pesticide Application Technology Laboratory in North Platte, Nebraska at the University of Nebraska-Lincoln. The experiment was conducted in a completely randomized design with four replications in two experimental runs. Kochia (*Bassia scoparia* (L.) A. J. Scott Weeds) were grown to 20-25 cm height under greenhouse conditions and were sprayed in a three-nozzle spray chamber at 207 kPa with the following herbicides: glyphosate, unformulated glyphosate, glufosinate, carfentrazone-ethyl, dicamba, and mesotrione. Each herbicide was applied at 2.3 L ha^{-1} and 93.5 L ha^{-1} with AIXR11002, TXR8002, XR8002, and TXR8002 nozzles. Plants were harvested 28 days after treatment, dried to a constant weight and biomass was recorded. Data were subjected to ANOVA with Fisher's least significant difference procedure at $\alpha = 0.05$. Biomass was influenced by the interaction of carrier volume*nozzle type*herbicide solution ($p<0.0001$). Overall, the results indicate that the smaller droplet producing nozzles paired with low volume applications had the highest level of control. Mesotrione, carfentrazone-ethyl, and glyphosate applications at 2.3 L ha^{-1} resulted in greater biomass control compared to applications at 93.5 L ha^{-1}, with the XR and TXR nozzles being the most effective nozzles. Glufosinate had higher levels of control at 93.5 L ha^{-1}, but also had the same level of control at 2.3 L ha^{-1} when using the XR nozzle. Glufosinate, glyphosate, dicamba, and mesotrione treatments had collapsed patterns when applied at 2.3 L ha^{-1}, particularly with AITX and AIXR nozzles. Overall, there were many herbicide, nozzle, and carrier volume interactions that influenced efficacy levels with carrier volume being the most important. sUAV applications add a new method of pesticide application, but nozzle by herbicide interactions can result in poor control, therefore it is important to understand which combinations will provide adequate efficacy.

†Herbicide Deposition and Coverage on Waterhemp (*Amaranthus rudis*) as Influenced by Spray Nozzle Design and Weed Density. Madison D. Kramer*[1], Travis R. Legleiter[2]; [1]University of Kentucky, Lynn, IN, [2]University of Kentucky, Princeton, KY (116)

ABSTRACT

Dicamba injury to sensitive soybean and other broadleaf crops due to drift has been a major concern and a series of restrictions have been created for dicamba applications. One restriction is the use of low drift nozzles that have been approved to spray dicamba, these nozzles produce extremely coarse and ultra-coarse droplets and minimize the production of driftable fines. Two experiments were conducted during the summer of 2019 at a farm located in Princeton, Kentucky to evaluate herbicide coverage and deposition on *Amaranthus rudis*. Specifically, looking at the influence of spray nozzle design and weed density. Dicamba plus glyphosate was applied to 5 to 10 cm tall weeds with a Turbo TeeJet (TT11005) nozzle and two drift reduction nozzles approved for dicamba applications: Turbo TeeJet Induction (TTI11005) and Pentatir Ultra Lo-Drift (ULD12005). Weed densities were categorized into three sections represented by 25%, 50%, and 100% of the natural density and established in a 0.25 cm^2 quadrant prior to post application. Fluorescent dye (PTSA) and pink foam marker dye were added to the spray solution to evaluate deposition on target leaf surfaces within the soybean canopy and evaluate coverage on Kromekote spray cards, respectively. Applications were made with an ATV traveling at 16 kph with an output of 140 L ha^{-1}. The percentage of coverage and depositions per cm^2 was less for the two drift reduction nozzles as compared to the Turbo TeeJet. Deposition of spray solution on to targeted weeds was not different despite differences observed on the Kromekote cards. *Amaranthus rudis* control rating observed 21 days after treatment was reduced by both the increased density treatments, as well as in one treatment where applications were made with the Turbo Tee Induction nozzle. The results from this research has shown that drift reduction nozzles and weed density can potentially affect herbicide efficacy on *Amaranthus rudis.*

Buffer Zone Width Effect on Spray Drift from Applications on Soybean and Corn Using an Air Induction Nozzle. Guilherme S. Alves*, Bruno C. Vieira, Milos Zaric, Barbara Vukoja, Arthur F. Teodoro Duarte, Pedro H. Alves Correa, Kasey P. Schroeder, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (117)

ABSTRACT

Buffer zones are used to protect the environment and sensitive vegetation against spray drift from pesticide applications. Besides application methods, nozzle type, physicochemical properties of spray solutions, sensitivity of non-target organisms, and meteorological conditions, adequate buffer zone width may depend on crop type. The objective of this study was to evaluate the effect of buffer zone width on spray drift reduction from applications over soybean and corn using air induction nozzles. A randomized complete block design with eight replications was used in a 3 x 2 split-plot arrangement [buffer zone width (main plot) versus crop (sub-plot)]. Buffers of 0, 5, and 10 m wide were used. Applications were performed when soybean and corn were 76-cm tall at R5 and V8 growth stages, respectively. Each replication was consisted of one sprayer pass 50 m long for each crop. A self-propelled sprayer with 33-m boom was used at 2.4 m s^{-1} travel speed to deliver 140 L ha^{-1} through 40 AIXR11004 nozzles (Air Induction Extended Range) at 274 kPa. The boom height was set at 76 cm above canopy. Solution was composed of water and a tracer (rhodamine at 0.25 % v v^{-1}). Mylar cards (25 x 25 cm) were used as collectors and placed 10 m downwind from the edge of the field. Mylar cards were line up side by side spaced 3 m apart and placed 38 cm above ground level. After applications, samples were collected and placed individually into pre-labeled plastic bags. A 40 mL aliquot of distilled water was added to each bag and once the tracer was suspended in solution, fluorescence data from each sample was measured using a fluorimeter. During the applications, wind speed ranged from 2.8 to 5.4 m s^{-1}. No interaction between buffer zone width and crop was observed. Regardless of buffer zone width, applications over soybean and corn produced similar spray drift (0.5%) at 10-m downwind from field edge. A 10-m buffer zone decreased spray drift in 2-fold when compared to no buffer zone. Conversely, buffer zones of 5 and 10 m produced similar spray drift (0.4%). Results suggest that buffer zones can be used to reduce drift from pesticide applications; however, more research needs to be conducted to adjust their widths depending on the composition of spray solution, nozzle type, and sensitivity of nearby non-targets. Adjustments on buffer zone widths may reduce the evolution of insecticide-, fungicide-, and herbicide-resistance, and increase crop yields with less damage to the environment.

Effect of Crosswind Shear in Production of Driftable Fine Droplets. Steven A. Fredericks*, Andrea C. Clark, Lillian C. Magidow, Daniel C. Bissel, Lee A. Boles, Gregory K. Dahl, Elizabeth R. Alonzi, Joe V. Gednalske; Winfield United, River Falls, WI (118)

ABSTRACT

Typical spray measurement methods, such as low speed wind tunnel testing or spray chamber analysis, are performed with either no wind or wind coflowing with the spray. This is in contrast to field application, where the ambient meteorological conditions and sprayer travel speed will combine to create a crosswind. This difference in flow conditions around the spray can change the atomization process and shift the resulting droplet sized distribution. High speed shadowgraphy in a low speed wind tunnel was performed on sprays containing a viscosity modifying drift reducing adjuvant to qualitatively compare the lamella breakup process in both coflowing and crosswind orientations. The spray with coflowing air was observed to exhibit ligament mediated breakup. The crosswind oriented spray was observed to exhibit bag breakup, wherein portions of the lamella were inflated by the crossflow, creating a thin liquid membrane supported by thicker adjacent portions of the lamella. The thin membrane then ruptured into a cloud of fine droplets. These droplets were quantified via phase Doppler interferometry measurements performed directly downwind of the lamella. The addition of an oil emulsion based drift reduction technology was found to prevent the formation of these bag membranes in the crosswind condition, returning the atomization to a ligament mediated process, and thereby reduce the number of driftable droplets produced.

Assessment of Commercial Scale Dicamba and 2,4-D Drift Using Drift Reducing Adjuvants. Ryan J. Edwards*, Steven A. Fredericks, Lillian C. Magidow, Gregory K. Dahl, Joe V. Gednalske, Mark A. Risley; Winfield United, River Falls, WI (119)

ABSTRACT

Off target movement of dicamba and 2,4-D herbicides must be minimized by pesticide applicators using technologies effective in reducing the off target movement. Off target dicamba movement has been shown to be reduced when drift reducing adjuvants are added to spray mixtures. With the commercialization of the new 2,4-D technologies, drift reduction when combined with tank-mixtures and adjuvants required investigation. A commercial scale sprayer was used to assess the effects of different drift reducing materials when applied in windy field conditions. Data were collected downwind using repeated horizontal transects, air samplers and NDVI images from a fixed wing drone. Results showed drift reductions when paired with adjuvants were specific to the two chemistries tested. With dicamba, off target drift was greater than with 2,4-D regardless of adjuvant addition. When adjuvants were added to tank mixtures, visible reductions in off target movement were achieved.

Adjuvants and Tank-Mix Products Influence the Performance of the New Dicamba and 2,4-D Herbicides. Gregory K. Dahl*, Ryan J. Edwards, Joe V. Gednalske, Lillian C. Magidow; Winfield United, River Falls, WI (120)

ABSTRACT

Studies were conducted with the new dicamba and 2,4-D herbicides in and prior to 2019. The studies consisted of field efficacy and drift studies, wind tunnel spray analysis studies and chemical compatibility studies. Products tested with the 2,4-D and dicamba herbicides included other herbicides, insecticides, fungicides, adjuvants, fertilizers and other products.

The performance of dicamba tank-mixtures for controlling weeds was increased when dicamba was used with non-AMS water conditioning adjuvants. The performance of 2,4-D tank-mixtures for controlling weeds was increased when used with AMS containing adjuvants or with non-AMS water conditioning adjuvants. Oil adjuvants and surfactant adjuvants were able to improve weed control with tank mixtures containing the 2,4-D or dicamba herbicides.

Drift reducing adjuvants were able to decrease the amount of spray that consisted of driftable fine droplets with either new 2,4-D or dicamba herbicides. Many products were able to be tank-mixed with the new 2,4-D or dicamba herbicides alone or with drift reducing adjuvants without adversely affecting spray drift quality.

Many products were compatible with at least one of the 2,4-D or dicamba technologies. Some products were compatible with all of the new technologies. There were many products that were not compatible with at least one of the new technologies.

†Optimal Herbicide and Timing for Control of Weeds Surviving Auxin Herbicides. Tomas F. Delucchi*, Bryan G. Young, William G. Johnson; Purdue University, West Lafayette, IN (121)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri* S. Watts) and tall waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] are two of the most troublesome weeds in US soybean production. Auxin herbicides, enabled by herbicide resistance traits in soybean, are currently used as postemergence tools to improve management of these two species. However, complete control of these species with 2,4-D or dicamba is not always achieved due to adverse environmental conditions, plant factors or misapplications. In these instances, a subsequent postemergence herbicide is required to control any plant that survived the first auxin herbicide application. Most frequently, the sequential herbicide application is the same herbicide that failed in the first application, which does not represent a sound resistance management strategy and may not be the most effective herbicide option. The objectives of this research were to determine which postemergence herbicide may be the most effective on Palmer amaranth and tall waterhemp that survived a 2,4-D or dicamba application and how many days the respray should be delayed to obtain the greatest efficacy. When 2,4-D was the initial herbicide consistent control of tall waterhemp resulted across the three respray application timings (7, 14 and 21 days after the initial application) for glufosinate, 2,4-D and dicamba. Fomesafen was the exception with an observed reduction of at least 28% when delaying the application to 14 and 21 days after the initial herbicide application. This same delay between dicamba applied first followed by the sequential herbicides resulted in a high degree of variation in control of tall waterhemp, but no statistical differences across the three timings. When applied to Palmer amaranth plants that survived a 2,4-D application, reductions in herbicide efficacy of up to 30% were observed for dicamba, glufosinate, and fomesafen applied 21 days after 2,4-D. However, 2,4-D followed by 2,4-D resulted in less control of Palmer amaranth than glufosinate and fomesafen when applied 7 days apart. The decline in herbicide efficacy with the longer delay in the sequential herbicide application was also observed on Palmer amaranth that survived an initial application of dicamba. Likewise, applying dicamba followed by dicamba resulted in less control of Palmer amaranth than glufosinate applied at either 7 or 14 days after the initial dicamba application. The timing of the sequential herbicide application proved to be an important factor affecting weed control, explaining the need for early resprays as soon as failure is detected (within 14 days). This research suggests that the use of an auxin herbicide followed by the same auxin herbicide may not be the best option for control of failed applications especially on Palmer amaranth, in addition to being a less desirable approach for resistance management.

†Importance of Sprayer Tank Clean-Out Following Dicamba Application. Jerri Lynn Henry*[1], Reid J. Smeda[1], Jason W. Weirich[2]; [1]University of Missouri, Columbia, MO, [2]MFA-Inc, Columbia, MO (122)

ABSTRACT

Dicamba-tolerant (DT) soybeans (*Glycine max*) were released to the market in 2017, and resulted in concerns regarding off-target movement of dicamba to adjacent, sensitive crops. One avenue for off-target movement is incomplete cleaning of commercial spray systems following applications of dicamba, and then making sequential herbicide applications on sensitive crops. The question at hand is if current sprayer cleaning procedures are adequate to remove dicamba from the tank and sprayer system components. Commonly, a triple rinse process is used to clean spray equipment. Cooperating with commercial applicators, rinsate samples from the third rinse were collected from 2017 to 2019 and dicamba concentrations were quantified using liquid chromatography coupled with a single quadrupole mass spectrometer. Dicamba concentrations in rinsate samples were then compared to a previously generated response curve to determine if rinsate dicamba concentrations could result in damage to sensitive soybean. Of the samples collected in 2017 (n=7), over 25 and 40% contained dicamba concentrations of 5-10 (n=2) and over 20 ppm (n=3), respectively. In 2018 (n=6), 15% of rinsate samples contained dicamba concentrations over 15 ppm (n=1), with the average rinsate containing approximately 1 ppm (n=5). In 2019 (n=12), 41% of rinsate samples exceeded 50 ppm (n=5). Some dicamba concentrations found in rinsate samples would be sufficient to visually damage plants and potentially result in yield losses for sensitive soybean. This study suggests applicators must be vigilant to clean out spray equipment using a triple rinse procedure. Continued research and monitoring of rinsate procedures are needed to correlate residual dicamba concentrations within commercial sprayers to injury at the field level.

†Effect of Adjuvants Associated with Herbicide Tank-Mixtures on Weed Control. Ely Anderson*, Jeffrey A. Golus, Bruno C. Vieira, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (123)

ABSTRACT

Future applications in soybean are likely to be composed of combinations of glufosinate and glyphosate for weed control. Surfactant systems are well documented to increase efficacy of both products despite having very different modes of action. The objective of this research was to determine how experimental adjuvant systems could impact the efficacy of combinations of glufosinate and glyphosate. Research was conducted at the University of Nebraska's Pesticide Application Technology Laboratory located in North Platte, NE to monitor interactions of unformulated glufosinate and unformulated glyphosate (Touchdown Hi-Tech) alone and in tank solution with two anionic surfactants on five weed species. Weed species grown included common lambsquarters (*Chenopodium album* L.), velvetleaf (*Abutilon theophrasti* Medik), common waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer), barnyard grass (*Echinochloa crus-galli* (L.) P. Beauv), and large crabgrass (*Digitaria sanguinalis* (L.) Scop*)* and were grown to a height of 15 – 20 cm tall. Plants were treated using an AI95015EVS at 140L ha-1 in a single nozzle spray chamber. Plants were evaluated at 7, 14, 21, and 28 days after application. Above ground biomass was harvested at 28 DAT and oven dried (65 C) to a consistent biomass. Dry plant biomass was recorded and data was analyzed using ANOVA where means were separated using $\alpha = 0.05$. The addition of an anionic surfactant to glufosinate greatly increased weed control across species except for common waterhemp. The addition of either anionic surfactant tested with an unloaded glyphosate tank solution increased weed control except on common waterhemp and velvetleaf. Mixtures of glufosinate and glyphosate with either anionic surfactant increased control of barnyard grass, large crabgrass, and common lambsquarters when compared to glufosinate and glyphosate alone. This study illustrates that antagonism of glufosinate mixtures with glyphosate can be overcome when using unformulated products and different anionic surfactants in tank solutions. Adding an anionic surfactant to a tank solution of glufosinate alone or glufosinate plus glyphosate increased weed control for some weed species.

Papers: Agronomic Crops I - Corn

†Control of Glyphosate/Glufosinate-Resistant Volunteer Corn in Corn Resistant to Aryloxyphenoxypropionate. Adam Striegel*[1], Nevin C. Lawrence[1], Stevan Z. Knezevic[1], Jeffrey Krumm[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Corteva, Hastings, NE (124)

ABSTRACT

Corn-on-corn production systems are common on highly productive irrigated fields in southcentral Nebraska. This rotation creates management issues with volunteer corn in corn fields. Enlist™ is a new trait conferring resistance to 2,4-D choline, glyphosate, and the aryloxyphenoxypropionate chemical family (FOPs) in the acetyl CoA carboxylase (ACCase) inhibitor site of action group. The objectives of this project were to (1) evaluate ACCase-inhibiting herbicides for control of glyphosate/glufosinate-resistant volunteer corn in Enlist™ corn, (2) evaluate effect of volunteer corn height (30 or 50 cm) on efficacy of ACCase-inhibiting herbicides, and (3) determine the effect of ACCase-inhibiting herbicides on Enlist corn injury and yield. Field experiments were conducted in 2018 and 2019 at South Central Agricultural Laboratory in Clay County, Nebraska. Volunteer corn was cross-planted at 40,000 plants ha^{-1} a week prior to planting the Enlist hybrid at 91,000 plants ha^{-1}. Application timing of fluazifop, quizalofop, and fluazifop/fenoxaprop (aryloxyphenoxypropionates) had no effect on crop yield or crop injury and volunteer corn control at 28 DAT. However, the 50 cm application of clethodim and sethoxydim (cyclohexanediones) and pinoxaden (phenylpyrazolin) increased crop injury and reduced crop yield in comparison to the 30 cm application, with the 30 cm application resulting in higher volunteer corn biomass reduction compared to the 50 cm application at 21 DAT. While all aryloxyphenoxypropionate products resulting in 99% control of the volunteer corn with no associated yield losses, quizalofop is the only labeled product for use in Enlist™ corn systems and can safely be applied to V2-V6 corn.

Control of Multiple-Herbicide-Resistant Waterhemp (*Amaranthus tuberculatus*) in Corn with Single- and Two-Pass Weed Control Programs. Christian A. Willemse*; University of Guelph, Ridgetown Campus, Parkhill, ON (125)

ABSTRACT

Multiple-herbicide-resistant (MR) waterhemp is becoming increasingly difficult to control due to the evolution of resistance to herbicide Groups 2, 5, 9 and 14. Field studies were conducted in Ontario in 2018 and 2019 to determine if MR waterhemp can be effectively controlled with 4-hydroxyphenylpyruvate dioxygenase (HPPD)-inhibiting herbicides applied postemergence (POST), and if two-pass herbicide programs provide greater and more consistent control of MR waterhemp than single-pass programs in corn. The control of MR waterhemp with the HPPD-inhibiting herbicides isoxaflutole, mesotrione, topramezone, tembotrione and tolpyralate with and without the addition of atrazine was evaluated. At 4 WAA, the addition of atrazine to isoxaflutole, mesotrione, topramezone and tembotrione improved MR waterhemp control from 71 to 86, 81 to 92, 79 to 86 and 90 to 97%, respectively. Tolpyralate controlled waterhemp 90% which was not increased with the addition of atrazine. Single- and two-pass programs for MR waterhemp control were evaluated in one study by applying isoxaflutole + atrazine, s-metolachlor/mesotrione/bicyclopyrone/atrazine and tolpyralate + atrazine preemergence (PRE), with and without a POST application of glufosinate. A second study evaluated waterhemp control by applying s-metolachlor + atrazine, saflufenacil/dimethanamid-p and dicamba/atrazine PRE, with and without mesotrione + atrazine POST. At 4 WAA, isoxaflutole + atrazine and tolpyralate + atrazine, followed by POST applications of glufosinate, increased MR waterhemp control from 90 to 97 and 84 to 96%, respectively. At 8 WAA, s-metolachlor/atrazine and dicamba/atrazine, followed by POST applications of mesotrione + atrazine, increased MR waterhemp control from 95 to 99 and 88 to 99%, respectively. Saflufenacil/dimethanamid-P PRE provided 98% MR waterhemp control and was not increased by a POST application of mesotrione + atrazine. This research identifies effective and consistent single- and two-pass herbicide programs for MR waterhemp in corn in Ontario.

†Investigating the Potential of Novel Synergistic Postemergence Tank Mixtures to Manage HPPD- and Atrazine-Resistant *Amaranthus tuberculatus* Populations. Kip E. Jacobs*, Carrie J. Butts-Wilmsmeyer, Chance W. Riggins, Dean E. Riechers; University of Illinois, Urbana, IL (126)

ABSTRACT

Field studies were designed to investigate the potential of two-way and three-way synergistic postemergence (POST) tank mixtures to manage HPPD-inhibitor and atrazine-resistant waterhemp (*Amaranthus tuberculatus*). Experiments were based on previous research that demonstrated increased control of waterhemp with PSII- and HPPD-inhibiting herbicides in combination compared to the expected sum of each herbicide applied alone. Studies were conducted at three locations in Illinois: two locations contained populations of HPPD- and metabolic atrazine-resistant waterhemp (CHR, Champaign County; MCR, Mclean County) and one location contained a HPPD- and atrazine-sensitive population at the University of Illinois Research Farm in Urbana. Bare ground experiments were conducted with a randomized complete block design comprised of a complete factorial arrangement of treatments with three replications. Waterhemp plants were treated at a height of 10 to 12 cm. Treatments included one of three commercial POST-applied HPPD-inhibitors (mesotrione, tembotrione, or topramezone) in combination with a reduced rate of the PSII-inhibitor metribuzin, the PDS-inhibitor norflurazon, or both to determine the efficacy and potential advantage of applying these herbicides in one, two, or three-way combinations. Control of emerged waterhemp plants was determined visually 7, 14, and 21 days after treatment (DAT) and aboveground biomass of previously marked plants (10 to 12 cm at time of application) was harvested at 21 DAT. Results indicate that mesotrione combined with metribuzin displayed the highest reduction in biomass among two-way tank mixtures. Among the three-way tank mixtures, only tembotrione plus metribuzin and norflurazon showed a significant biomass reduction relative to their respective two-way combinations. In summary, results from these experiments support previous findings of synergy between PSII and HPPD inhibitors. However, this research indicates the addition of a third site-of-action (PDS-inhibitors) to certain synergistic two-way mixtures could be a valuable resource for managing troublesome waterhemp populations and will be further investigated in future field, greenhouse, and lab research.

Response of a Five-Way-Resistant Palmer Amaranth Population to Preemergence Applied Mesotrione and Atrazine. Rui Liu*, Vipan Kumar, Taylor Lambert, Phillip W. Stahlman; Kansas State University, Hays, KS (127)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri* S. Watson) is one of the most problematic broadleaf weed species in agronomic crops across the mid-south and central United States, including Kansas. Rapid evolution of Palmer amaranth populations with resistance to multiple herbicide site(s) of action is an ever-increasing concern for growers in this region. We recently identified a Palmer amaranth population (MHR) from central Kansas with multiple resistance to POST-applied 2, 4-D (3.2-fold), glyphosate (11.8-fold), chlorsulfuron (5.0-fold), atrazine (14.4-fold), mesotrione (13.4-fold) and with reduced sensitivity to fomesafen (2.3-fold). The objective of this research was to determine the response of this MHR population to PRE-applied atrazine, mesotrione, and their tank-mixtures in dose-response assays. Progeny seeds obtained from MHR Palmer amaranth plants that survived atrazine (1120 g ae ha^{-1}) and mesotrione (105 g ha^{-1}) in a greenhouse study were used. In contrast, seeds of a known susceptible Palmer amaranth population collected from a site near Hays, KS were included for comparison. A greenhouse experiment was conducted at the Kansas State University Agricultural Research Center-Hays in 2019. Germination plastic trays (25.4 cm by 25.4 cm) containing field soil were used in dose-response assays. For each tested herbicide alone or in combination, separate dose-response experiments were conducted in completely randomized designs with four replications. One hundred and fifty seeds from MHR and SUS populations were separately sown on the soil surface of each tray. Doses of PRE-applied atrazine and mesotrione herbicides were 0, 1/4X, 1/2X, 1X, 2X, and 4X (1X of atrazine = 1120 g ha^{-1}; 1X of mesotrione = 105 g ha^{-1}). Tank-mixture combination of atrazine (1X) with mesotrione at 1/4X, 1/2X and 1X, as well as mesotrione (1X) with atrazine at 1/4X, 1/2X, 1X were also tested. The number of emerged Palmer amaranth seedlings from both populations at each tested herbicide dose were counted at 28 days after treatment (DAT). Seedling emergence data were analyzed in *R* software, using a 3-parameter log-logistic regression model. Results indicated the effective doses (ED_{50} values) of PRE- applied atrazine required for 50% reductions in seedling emergence of MHR and SUS populations were 3812 g ha^{-1} and 1262 g ha^{-1}, respectively indicating 3-fold resistance to PRE-applied atrazine in the MHR population. However, the ED_{50} values of MHR and SUS populations did not differ in response to PRE-applied mesotrione alone or all tank-mixed dosage combinations of atrazine and mesotrione herbicides. These preliminary results suggest that PRE-applied mesotrione alone or tank-mixtures of atrazine and mesotrione can still be used to effectively manage this five-way-resistant MHR Palmer amaranth population.

Influence of Adjuvants on the Control of Glyphosate-Resistant Canada Fleabane (*Conyza canadensis*) and Waterhemp (*Amaranthus tuberculatus*) in Corn with Tolpyralate. Nicole M. Langdon*[1], Darren Robinson[1], Dave Hooker[1], Alan J. Raeder[2], Peter Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]ISK Biosciences Inc., Concord, OH (128)

ABSTRACT

Tolpyralate is a new benzoylpyrazole, 4-hydroxyphenyl-pyruvate dioxygenase inhibitor, registered for use in corn, with recommended adjuvants methylated seed oil (MSO) concentrate plus an ammonium nitrogen fertilizer such as UAN. Since 97% of the corn acreage in Eastern Canada is seeded to Roundup Ready® hybrids, the common use pattern for tolpyralate + atrazine will be tankmixed with glyphosate. Two field studies were completed on two problem weeds in Ontario: glyphosate-resistant (GR) Canada fleabane and waterhemp. The objective of both studies was to determine if an additional adjuvant is required when tolpyralate plus atrazine is tank-mixed with glyphosate. Each study consisted of six field experiments conducted over a two-year period (2018-19) on farms in southwestern Ontario with confirmed multiple-herbicide-resistant populations. At 4 WAA, the addition of glyphosate to tolpyralate + atrazine increased control of GR Canada fleabane and waterhemp by 18 and 10%, respectively. In the presence of glyphosate, the addition of MSO to tolpyralate + atrazine increased control of GR waterhemp 9%, however, no increase was observed from the addition of additional adjuvants for GR Canada fleabane control. At 8 WAA, all treatment provided >91% control of GR waterhemp and >84% control of GR Canada fleabane. This study concludes that the adjuvant system plays a role in herbicidal enhancement of tolpyralate plus atrazine and activity of may be further improved with the addition of MSO.

†Modelling Effectiveness of Preemergence Herbicides Used on Corn Across Varied Weather Conditions. Christopher Landau*[1], Adam Davis[1], Aaron G. Hager[1], Nicholas F. Martin[1], Patrick J. Tranel [1], Martin Williams[2]; [1]University of Illinois, Urbana, IL, [2]USDA, Urbana, IL (129)

ABSTRACT

Preemergence (PRE) herbicides remain one of the most commonly used weed management tools in corn (*Zea mays* L.). Precipitation amount and soil temperature within the first 15 days after treatment (DAT) have been reported to influence the efficacy of most PRE herbicides. However, much of the previous research utilize a limited number of site years, which may not adequately characterize the full effects of precipitation and soil temperature on PRE herbicide efficacies. The objective of this study was to model probability of acceptable weed control from common PRE herbicides across a broad range of environmental conditions. A large database of 2,700 independent herbicide evaluation trials, conducted from 1992 to 2016, was utilized. Each trial contained control ratings for different weed species treated with different herbicides. Weed species varied by trial, but the most common species throughout the database were waterhemp (*Amaranthus tuburculatus* (Moq.) J. D. Sauer), common lambsquarters (*Chenopodium album* L.), and giant foxtail (*Setaria faberi* Herm.). Additionally, six PRE herbicide treatments comprised a majority of the database: atrazine, acetochlor, S-metolachlor, atrazine + acetochlor, atrazine + S-metolachlor, and atrazine + S-metolachlor + mesotrione. Data for total precipitation and average soil temperature 15 DAT were obtained from the Illinois State Water Survey and added to each trial. Total precipitation 15 DAT ranged from 0.1 to 18.6 cm and average soil temperature 15 DAT ranged from 12.3 to 27.6 °C throughout the trials. This variation in precipitation and soil temperature created 252 unique, testable, environments. Logistic regression was used to model probability of weed control from six PRE herbicides across the diverse environments. The probability of controlling waterhemp, common lambsquarters, and giant foxtail with all treatments increased with precipitation accumulation 15 DAT, and most treatments required 5-10 cm of precipitation to maximize the probability of control. The effect of temperature on weed control was dependent on precipitation. When precipitation 15 DAT was ≥ 5 cm, probability of weed control was not influenced by soil temperature. However, when precipitation 15 DAT was < 5 cm, increasing soil temperature led to unique outcomes depending on treatment and weed species. This work quantifies the role major environmental drivers have on PRE herbicide efficacy using an inference space far larger than previously attempted.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

†Evaluating the Impact of Weed Competition and Water Stress on Corn Hybrids with Differing Drought Tolerance. Allyson M. Rumler*, Erin Burns; Michigan State University, East Lansing, MI (130)

ABSTRACT

Water is a critical abiotic stress that is often the most limiting factor for crop growth and yield. Reduced precipitation during the flowering reproductive stage of corn (*Zea mays*) can significantly impact grain fill and ultimately lead to ovule abortion. Aside from water stress, weed competition is a critical biotic stress that can be another limiting factor for crop growth and development. Genetic improvements have been made to improve corn tolerance to water stress. However, little to no research has evaluated how these improvements will perform when under extreme water stress and varying weed pressures. With the expected change in precipitation throughout the Great Lakes Region a field study was conducted in East Lansing, Michigan in 2019 to evaluate the impacts of weed competition and water stress on corn hybrids with differing drought tolerance. The study followed a split-plot randomized block design with four replications. Whole plots were assigned to a corn hybrid with or without the Genuity® DroughtGard® trait. Sub-plot treatments were factorial combinations of one of three weed pressures (weed-free, 50% weeds, 100% weeds) and two water stress treatments (reduced or ambient). Reduced plots contained rainout shelters that were designed to intercept 70% of the total rainfall. Corn growth and development was measured on 10 tagged plants and occurred at four significant growth stages known to be impacted by drought (V6, V12, VT/R1, R3/R4). Weed density by species was measured three times during the season. Weed biomass by species was collected at the end of the season. At harvest, the dominant corn ear from the 10 tagged plants were individually harvested for yield component analysis. The dominant weed species included: annual grasses, common lambsquarters (*Chenopodium album*), horseweed (*Conyza canadensis*), and common purslane (*Portulaca oleracea*). Weed density was not impacted by corn hybrid. However, weed density was lower under reduced precipitation than under ambient precipitation ($p=0.003$). Furthermore, weed communities under reduced precipitation were more diverse than weed communities under ambient precipitation ($p=0.099$). Additionally, species evenness was found to be more uniform under reduced precipitation ($p=0.001$). There was a significant three-way interaction with the factorial combination of hybrid, weed pressure, and water stress ($p=0.011$). In general, corn yield was reduced as weed pressures increased. In a weed free environment, hybrids under reduced precipitation had a yield decrease of 23% when compared to the non-drought tolerant hybrid under ambient precipitation. When increasing weed pressure to 50% and under reduced precipitation drought tolerant hybrid yield decreased by 27% when compared to the non-drought tolerant hybrid under the same conditions. However, when increasing the weed pressure to 100% and under reduced precipitation drought tolerant hybrid yield decreased by 31% when compared to the drought tolerant hybrid under ambient precipitation. Results thus far indicate that water stress does impact corn yield of both hybrids and that this result is modified by weed competition. Results demonstrate water stress changes weed density and community composition, therefore integrated weed management plans will need to adapt to these changes for continued success.

†Does Corn Silage Leaf Angle Modify the Critical Period of Weed Control in Alfalfa Interseeded with Corn? Sarah A. Drumm*, Erin Burns; Michigan State University, East Lansing, MI (131)

ABSTRACT

Alfalfa (*Medicago sativa*) acres in Michigan are declining due to farmers relying on silage corn (*Zea mays*) as a continuous feed source partly due to low alfalfa yield in the establishment year. By adopting an intercropped system of corn silage and alfalfa, farmers can replace low first year alfalfa yield by substituting silage yield, while simultaneously establishing a healthy alfalfa stand for the proceeding years. The objective of this study is to evaluate how corn silage hybrid leaf architecture modifies the critical weed control period and weed seed dynamics in an alfalfa silage corn interseeded system. To address this objective a field study was conducted in East Lansing, MI in 2019. The study followed a randomized complete block design with four replications. Whole plots were assigned to one of two silage corn hybrids with differing leaf architecture: upright vs. pendulum. Sub-plots were assigned to one of eight weed removal/addition timings. A glyphosate resistant alfalfa variety was planted on the same day as corn planting. To establish uniform densities and emergence patterns a surrogate weed, Japanese millet (*Echinochloa esculenta*), was used. Treatments to establish the critical duration allowed weeds to emerge with the alfalfa/corn at planting followed by removal with glyphosate at 2, 4, 6, and 8 weeks after planting. Treatments to establish the weed-free period were maintained weed free with glyphosate until 2, 4, 6, and 8 weeks after planting, at which time the millet was planted. Weed-free and weedy plots were included as controls. Data was collected on percent cover, corn height, stage, and leaf angle, alfalfa and millet height, and canopy closure. The data was measured at each addition/removal, and prior to harvest. Japanese Millet seed production was collected at the end of the season and viability assessed using tetrazolium testing. There was no difference in the critical time for weed removal between upright and pendulum silage hybrids ($p = 0.54$). The critical time of weed removal occurred 338 and 449 growing degree days after planting for pendulum and upright hybrids respectively. The presence of interseeded alfalfa did not reduce yield compared to corn only treatments ($p = 0.76$). Corn yield decreased when weeds were removed 4, 6, and 8 weeks after planting compared to all other timings ($p < 0.001$). Alfalfa yield was negatively impacted when weeds were allowed to compete for 6 and 8 weeks compared to all the other treatments ($p < 0.0001$). Plots interseeded with alfalfa did not reduce weed seed production compared to solo seeded corn ($p = 0.59$), although the viability of seeds produced differed among treatments ($p = 0.07$). Interseeding reduced weed seed viability by 56% compared to corn only treatments. There was no difference in panicle number ($p = 0.18$) or seeds per panicle ($p = 0.39$) among treatments in weedy control plots. Results demonstrate that the critical time for weed removal in this interseeded system is approximately 390 growing degree days and interseeding reduces weed seed viability.

†Interactions Between Cereal Rye and Residual Herbicides on Giant Ragweed and Grass Control in Corn. Wyatt S. Petersen*, William G. Johnson; Purdue University, West Lafayette, IN (132)

ABSTRACT

Cereal rye is a popular Midwest cover crop used in part for its weed-suppressive abilities. However, as a high-biomass cover crop, its impact on residual herbicide efficacy is unclear, as above-ground residue may intercept residual herbicides, which can prevent contact with weed seed. Field studies were conducted in 2018 and 2019 at Throckmorton Purdue Agricultural Center near Lafayette, IN to assess the impact of residual herbicide application strategies in cereal rye-corn systems. All plots received a burndown application of glyphosate or glyphosate + a residual herbicide premix at corn planting on June 3 to terminate the cereal rye. A POST application was made using glyphosate + dicamba + diflufenzopyr on June 26. Half of the POST herbicide applications also contained atrazine + acetochlor. Giant ragweed (*Ambrosia trifida*) and summer annual grass (*Poaceae* spp.) biomass and densities were recorded separately preceding the POST application made three weeks after corn planting. Late-season grass biomass and densities were also recorded in October to assess treatment effects on season-long weed control. Summer annual grass density and biomass were more affected by the cereal rye cover crop than was giant ragweed. The residual herbicide premix at burndown effectively controlled all grass species in both cereal rye and fallow treatments in both years (98 to 100% control). Differences between years was likely due to the difference in cereal rye biomass. Average cereal rye biomass was 3500 and 6200 kg ha^{-1} in 2018 and 2019, respectively. Summer annual grass density was reduced in 2019, but not 2018. Giant ragweed density was not reduced in either year. Residual herbicide application timing did not have any effect on late-season grass control, however fallow plots that received any residual herbicide application resulted in at least a 90% reduction in grass density. Cereal rye residue reduced late-season grass density in treatments where no residual herbicide was applied compared to fallow treatments by 93%, however this was only observed in 2019. Residual herbicide efficacy was not compromised by a cereal rye cover crop, and therefore both cereal rye and residual herbicides can coexist in an integrated herbicide resistance management system.

†Impact of Cereal Rye Termination on Acetochlor Efficacy on Weed Control. Lucas Oliveira Ribeiro Maia*, Wyatt Petersen, William G. Johnson; Purdue University, West Lafayette, IN (133)

ABSTRACT

Weed suppression is one goal for many cover crop growers. To achieve this goal, some growers may delay cover crop termination. Residual herbicides provide weed control over extended periods as opposed to foliar herbicides and can be an effective herbicide resistance management tool. To this extent, the combination of cover crops and residual herbicides must be considered in any integrated weed management program. To assess the efficacy of acetochlor on weed control when applied at different cover crop termination timings, a field trial was conducted at the Throckmorton Purdue Agricultural Center, Tippecanoe, Indiana, from Fall 2018 to Fall 2019. Treatments included cereal rye (*Secale cereale* L.), cereal rye mixed with crimson clover (*Trifolium incarnatum* L.), and a fallow treatment, as well as three termination timings [two weeks before corn planting (WBP), at planting, and two weeks after planting (WAP)] and three herbicide termination programs (glyphosate + atrazine, glyphosate + atrazine + dicamba, and glyphosate + atrazine + dicamba + acetochlor). Cover crop biomass was collected the day of cover crop termination. Weed biomass was collected four WAP before a post emergence herbicide application of glyphosate, atrazine, S-metolachlor, dicamba, and diflufenzopyr. The cereal rye biomass for the early, at-planting, and late terminations were 2247, 8848, and 10000 kg ha^{-1}, respectively. The mixed species cover crop biomass for the early, at-planting, and late terminations were 2236, 8127, and 10960 kg ha^{-1}, respectively. Later cover crop termination resulted in lower weed biomass 4 WAP. The addition of acetochlor to the tank mix provided 4-fold greater suppression of grassy weeds relative to the tank mix without this herbicide, in fallow treatments. The combination of cover crops and the herbicide tank mix that included acetochlor resulted in 7.6-fold lower grass weeds density relative to fallow plots that were sprayed with a tank mix without acetochlor. Results from this study indicated a supplemental effect of cover crops and the soil residual herbicide acetochlor on weed suppression, particularly of grasses. To maximize weed control, growers should focus on an integrated weed management program that comprises cover crops and soil residual herbicides.

The Bicyclopyrone Weed Control Advantage in a New Premix Product Concept for Corn. Ryan Lins*[1], Scott Cully[2], Tom Beckett[3], Gordon Vail[3]; [1]Syngenta Crop Protection, Rochester, MN, [2]Syngenta, Marion, IL, [3]Syngenta, Greensboro, NC (134)

ABSTRACT

Acuron® GT is a new herbicide coming soon from Syngenta for weed control in glyphosate tolerant field corn. Acuron GT will contain S-metolachlor, mesotrione, bicyclopyrone and glyphosate for postemergence application with knockdown and residual control of grasses and broadleaves. In 2019, field trials were conducted to evaluate Acuron GT for weed control and crop tolerance. Results show that Acuron GT effectively controls many difficult weeds and provides improved residual control and consistency compared to other commercial standards. Acuron GT is not registered for sale or use in the US and is not being offered for sale.

BCS-720: A New Residual Herbicide Combination for Weed Management in Corn. Mike Weber*[1], Mark Waddington[2], Eric Riley[2]; [1]Bayer CropScience, Indianola, IA, [2]Bayer CropScience, St. Louis, MO (135)

ABSTRACT

BCS-720 is a new residual herbicide combination developed by Bayer CropScience for weed management in corn and pending registration with the EPA. It will contain four key components: isoxaflutole, a Group 27 herbicide, thiencarbazone-methyl, a Group 2 herbicide, flufenacet, a Group 15 herbicide, cyprosulfamide, a safener. Upon registration BCS-720 will provide residual control of both grass and broadleaf weeds. BCS-720 will offer flexibility in application timing from early preplant burndown through the V2 stage of corn postemerge. With three herbicide SOA and novel safener, it will be an effective management tool which will fit well into either conventional or no-till systems for weed management.

Resicore® for PRE and POST Weed Control in Corn. Kevin Johnson*[1], Kevin Hahn[2], Joe Armstrong[3], David Saunders[4]; [1]Corteva Agriscience, Lafayette, IN, [2]Corteva Agriscience, Bloomington, IL, [3]Corteva Agriscience, Indianapolis, IN, [4]Corteva Agriscience, Johnston, IA (136)

ABSTRACT

NO ABSTRACT SUBMITTED

Introduction and Overview of MON 301107: A New Glyphosate Formulation. Ross A. Recker*[1], Christopher M. Mayo[2], David J. Mayonado[3], Robert F. Montgomery[4], Gustavo G. Camargo[1]; [1]Bayer, St. Louis, MO, [2]Bayer, Gardner, KS, [3]Bayer, Hebron, MD, [4]Bayer, Union City, TN (137)

ABSTRACT

MON 301107 is a new glyphosate formulation. Field trials conducted in 2017 and 2018 in 54 locations evaluated MON 301107 for postemergence weed control compared to commercial standards. The experimental design was a split-plot arrangement with 3-4 replications. Whole-plots consisted of different glyphosate rates and the sub-plots were various glyphosate formulations. Results from 2017-18 trials, 14 days after treatment, indicated MON 301107 at 1120 g a.e. ha^{-1} provided broadleaf control and grass control that was not statistically different than commercial standards at 1120 g a.e. ha^{-1}. Additional field trials conducted in 2019 evaluated crop safety of MON 301107 compared to Roundup PowerMAX® herbicide when used postemergence on multiple crops. The experimental design was a split-plot arrangement with 3-4 replications. Whole-plots consisted of different herbicide treatments and the sub-plots had either MON 301107 or Roundup PowerMAX as the glyphosate formulation utilized in the herbicide treatment. Glyphosate formulation was not a significant treatment factor for any of the percent injury evaluations for field corn hybrids with Roundup Ready® 2 Technology or Roundup Ready 2 Yield® soybean. These results demonstrate MON 301107 can provide non-selective foliar control of both grass and broadleaf weeds and has a comparable crop safety profile to Roundup PowerMAX.

Papers: Herbicide Physiology & Molecular Biology

The Complexities of Glyphosate-Resistant Kochia at a Field Level Including Abiotic Stress Tolerance. Philip Westra*, Todd Gaines, Franck Dayan, Andrew Effertz, Crystal D. Sparks; Colorado State University, Fort Collins, CO (138)

ABSTRACT

Kochia is a resilient well adapted weed in the great plains of North America where it has invaded most cropped and non-cropped ecosystems. It has a high propensity for developing resistance to different classes of herbicides including glyphosate. One mechanism of glyphosate resistance is gene duplication. The recent completion of the full kochia genomic sequence by Eric Patterson et al. provides a powerful tool for more detailed evaluation of these duplicated genes which are found in at least two different contig patterns, both of which include other genes which have also been duplicated. There may be yet other mechanisms of glyphosate resistance in kochia. Kochia tolerance of extreme abiotic stresses has been observed by different researchers, and now that we have a reference genome, we can begin to explore for the genetic basis of these tolerances.

New Insights into Target-Site and Non-Target-Site Resistance to Synthetic Auxin Herbicides. Todd A. Gaines*[1], Marcelo Figueiredo[1], Olivia E. Todd[1], Neeta Soni[1], Eric L. Patterson[2], Anita Kuepper[3], Chris Preston[4], Cris Argueso[1], Anireddy Reddy[1], Philip Westra[1], Franck Dayan[1]; [1]Colorado State University, Fort Collins, CO, [2]Michigan State University, East Lansing, MI, [3]Bayer CropScience, Hoechst, Germany, [4]University of Adelaide, Glen Osmond, Australia (139)

ABSTRACT

Evolved resistance to synthetic auxin herbicides in weeds is an issue of increasing importance. Building on the recent identification of a Gly to Asn substitution in the conserved degron of *IAA16* conferring discamba resistance in kochia (*Bassia scoparia*), we have investigated additional resistance mechanisms to dicamba in kochia, and 2,4-D resistance in Indian Hedge Mustard (*Sisymbrium orientale*). Dicamba resistant kochia populations from eastern Colorado were examined for the IAA16 mutation. Several carried the mutation, while others did not have the mutation, indicating a different mechanism may be present in some populations. In 2005, a 2,4-D resistant Indian Hedge Mustard population was identified in South Australia in a cereal field. This population required a dose of 22X to achieve the same levels of control as the susceptible population. Two resistant populations were collected at Port Broughton located 120 km from Roseworthy, where the susceptible population was collected. A segregating F2 generation had a ratio of 3 resistant to 1 susceptible, indicating single gene, dominant inheritance. Resistant and susceptible recombinant inbred lines (RILs) were developed by selfing F2 plants to reduce genetic background and produce homogeneous, homozygous F5 RILs. RNAseq was performed using 6 resistant and 6 susceptible RILs. Sequence variant analysis and differential expression analysis were performed. A 27 base pair deletion causing an in-frame 9 amino acid deletion was identified in the auxin receptor *IAA2*. This deletion was verified by KASP genotyping and co-segregated 100% with resistance in the F2. Transformed Arabidopsis lines expressing *IAA2Δ27* were 2,4-D resistant, while transgenic lines expressing wild-type *IAA2* were 2,4-D susceptible.

†A Novel TIPT Double Mutation in *EPSPS* Conferring Glyphosate Resistance in Tetraploid *Bidens subalternans*. Hudson K. Takano*, Philip Westra, Todd Gaines, Franck Dayan; Colorado State University, Fort Collins, CO (140)

ABSTRACT

Greater beggarticks (*Bidens subalternans* DC) is a tetraploid and troublesome weed infesting annual crops in most tropical and subtropical regions of the world. While glyphosate is considered the most successful herbicide in global agriculture, the number of glyphosate-resistant (GR) weeds keeps increasing every year. A GR *B. subalternans* biotype was detected in a soybean field from Paraguay, where glyphosate was applied up to seven times a year. The resistance mechanism was investigated in a series of greenhouse and laboratory experiments: whole-plant dose response, shikimate accumulation in leaf discs, ^{14}C-glyphosate uptake and translocation, glyphosate metabolism, *EPSPS* gene copy number, cloning and sequencing. The GR biotype showed high level of resistance (>15-fold LD_{50}), relative to a glyphosate-susceptible (GS) biotype. We found no differences in sensitivity when plants were treated and kept under lower (10/4 C) or higher temperatures (25/20 C) within the same biotype, indicating vacuole sequestration is unlikely. Shikimate accumulation was up to 10-fold greater for GS compared to GR. The two biotypes had the same relative *EPSPS* gene copy number, and similar ^{14}C-glyphosate absorption and translocation rates. In addition, neither biotype metabolized glyphosate into aminomethylphosphonic acid (AMPA), suggesting that these mechanisms do not contribute to GR. Genomic DNA sequencing provided ambiguous results for GR *EPSPS* because *B. subalternans* is a tetraploid species. Thus, we cloned GR *EPSPS* into *Escherichia coli* and sequenced 24 positive colonies containing only one version of the gene. A Kompetitive Allele Specific PCR (KASP) assay was performed with different proportions of each version of *EPSPS* present in GR. A double amino acid substitution (TIPT - Thr102Ile and Pro106Thr) was found in only one *EPSPS* allele from one of the two *EPSPS* homoeologs present in tetraploid GR *B. subalternans*. This is the first report of a TIPT double mutation conferring high levels of glyphosate resistance in a weed species. The presence of both wild-type and TIPT mutant *EPSPS* on the polyploid genome of GR *B. subalternans* may offset a potential fitness cost. Future research will investigate the fitness of GR plants along with the inheritance and distribution of the TIPT mutation within a population.

†Investigation of Novel Mechanism of Resistance to Lactofen in Palmer Amaranth. Jacob S. Montgomery*, Darci Giacomini, Patrick J. Tranel; University of Illinois, Urbana, IL (141)

ABSTRACT

During the 2017 growing season, samples of Palmer amaranth (*Amaranthus palmeri*) that had reportedly survived field-rate applications of lactofen were collected from the Midwest and tested for target-site mutations known to convey resistance to protoporphyrinogen-oxidase (PPO)-inhibiting herbicides. One population (W-8) tested negatively for all mutations leading to an investigation of this population and a previously undocumented resistance mechanism. Seeds from the sampled field were germinated and plants were confirmed to be resistant to lactofen, with an R:S ratio comparable to that conferred by the deletion of a glycine residue at the 210th amino acid position of protoporphyrinogen-oxidase II (PPX2). Gene sequences from W-8 PPX2 were compared to sequences of known PPO-inhibitor-sensitive PPX2. While sequence variation did exist, no missense mutations were discovered that delimited resistant plants (R) and sensitive plants(S) and amino acid positions 128 and 210 were unchanged from the wild type. Gene expression assays for protoporphyrinogen-oxidase I (PPX1) and PPX2 found no difference in constitutive or induced expression between R and S populations over a 4-hour period after lactofen application. To test the inheritance of this resistance trait, reciprocal F_1 populations were generated using W-8 as both the male and female parent. Lack of differential survival of their progeny indicated that this resistance was not maternally inherited. Progeny of each F_1 hybrid (full-sibs) were crossed to generate pseudo-F_2 populations, and also crossed back to plants from the sensitive parent population to produce backcross (BC1) populations. Pseudo-F_2 and BC1 plants were screened with a delimiting rate. Dead/alive ratings of F_2 and BC1 populations indicate that the resistance mechanism is caused by a single locus and was additive. Molecular markers for the PPX2 allele from the resistant parent were used to test for co-segregation of this allele with resistance in the pseudo-F_2 populations. Resistance segregated tightly with this allele, but there was recombination observed in pseudo-F_2 and BC1 populations. Future work will involve mapping this region and identifying the genetic basis of resistance in this population.

†Genetic Mapping of HPPD-Inhibitor Resistance in *Amaranthus tuberculatus*. Brent P. Murphy*, Patrick J. Tranel; University of Illinois, Urbana, IL (142)

ABSTRACT

Amaranthus tuberculatus (Moq.) Sauer is a predominant driver weed within Midwestern production agriculture. Herbicide resistance is a major and growing issue within the species, where resistance to herbicides encompassing seven sites of action, including to inhibitors of 4-hydroxyphenylpyruvate dioxygenase (HPPD), has been reported. Characterization of herbicide resistance may provide insights into its evolution and management. In contrast to target-site resistance, characterization of non-target-site herbicide resistance often requires non-targeted approaches. With the recent release of a high quality genome assembly for *A. tuberculatus*, genomics approaches to the investigation of non-target-site resistance in this species are now practical. HPPD-inhibitor resistance in Illinois and Nebraska populations of *A. tuberculatus* was characterized at the phenotypic and genomic levels. Segregating populations were created from paired plant crosses. Within the Illinois population, resistance ratios of 43 and 16.2 were observed in the parental and F1 generation, respectively. In contrast, resistance ratios of 15 and 21 were observed in the parental and F1 generation of the Nebraska population. Segregation of F2 populations suggests resistance may be controlled at multiple loci within both populations. Differences in the resistance ratios and in inheritance suggest resistance evolved independently in each of the two populations. Whole-genome and double-digest restriction-associated DNA sequencing were conducted to identify quantitative trait loci underlying herbicide resistance within both populations.

†Resistance to PPO-Inhibiting Herbicides in Palmer Amaranth: Are TSR and NTSR Mechanisms Co-Existing? Ednaldo A. Borgato*, Dallas E. Peterson, J. Anita Dille, Mithila Jugulam; Kansas State University, Manhattan, KS (143)

ABSTRACT

Target- (TSR) and non-target-site resistance (NTSR) to protoporphyrinogen-oxidase (PPO)-inhibitors have been reported in Palmer amaranth (*Amaranthus palmeri* S. Watson). While TSR mechanisms include mutations in *PPO* gene, the NTSR is generally conferred by herbicide detoxification via cytochromes P450 (CYP450s) and glutathione-s-transferases (GSTs). A Palmer amaranth population from Kansas (KCTR) collected from a long-term conservation tillage study survived the field recommended rate of various herbicides, including glyphosate, 2,4-D, ALS-, PSII-, HPPD- and PPO-inhibitors. The objective of this research was to confirm and characterize resistance to PPO-inhibitors on KCTR Palmer amaranth. The plants that survived PPO-inhibitors (lactofen and fomesafen) were allowed to mate separately in the greenhouse for subsequent studies and the seed samples were labeled as KCTR-L and KCTR-F, respectively. Dose-response experiments were performed to determine the level of resistance of KCTR to lactofen and fomesafen in comparison with two known susceptible populations, from Kansas (KSS) and Mississippi (MSS). Herbicide rates ranged from 1/16X to 8X, with 1X representing the field labeled rate of lactofen (240 g ai ha^{-1}) and fomesafen (420 g ai ha^{-1}). Aboveground biomass was harvested at 14 days after herbicide treatment and oven dried for measurement. The doses required to reduce biomass of KCTR, KSS, and MSS by 50% (GR_{50}) were estimated by non-linear regression with three-parameters model using the *drc* package in R. Additionally, to investigate the presence of NTSR mechanism, experiments were conducted using CYP450- and GSTs-inhibitors: malathion and 4-chloro-7-nitrobenzofurazan (NBD-Cl). Visual injury data were collected at 14 days after herbicide application and means separated by Fisher's protected LSD test. KCTR showed a GR_{50} of 65.2 g ai ha^{-1} to lactofen, whereas KSS and MSS were 4.1 and 10.8, respectively, with a level of resistance of 6- to 15.9-fold. The GR_{50} were estimated as 54.1, 9.9 and 7.7 for KCTR, KSS, and MSS, respectively, with 5.5- to 7-fold level of resistance for fomesafen, confirming that KCTR Palmer amaranth has evolved resistance to PPO-inhibitors. The addition of malathion or NBD-Cl prior to lactofen and NBD-Cl prior to fomesafen application resulted in higher injury in KCTR-L compared to those that were treated with herbicides alone, suggesting the role of CYP450s and GSTs in imparting metabolism-based resistance in KCTR-L. The evolution of metabolism-based NTSR mechanisms poses a huge threat to weed management because they are likely to confer resistance to a broad spectrum of herbicides.

†Utilizing Multiple, Effective Herbicide Modes of Action Can Strongly Influence Selection Pressure for ALS-Resistance in Giant Ragweed. Benjamin C. Westrich*, Bryan G. Young; Purdue University, West Lafayette, IN (144)

ABSTRACT

Cloransulam is an ALS-inhibiting herbicide frequently used to control giant ragweed (*Ambrosia trifida* L.) in soybean production. Heavy reliance on herbicides that target ALS has resulted in the spread of resistant biotypes, potentially limiting the future utility of cloransulam and other ALS-inhibiting herbicides. Resistance to ALS-inhibitors in giant ragweed is conferred by a dominant single-nucleotide polymorphism in the ALS gene (W574L). The presence of this high-level resistance mutation in giant ragweed populations necessitates the application of additional herbicide modes of action for effective control. Pending future approval and commercialization, the use of mesotrione in resistant soybean varieties will allow for new herbicide mixtures to be applied for control of giant ragweed. In an effort to examine how these herbicide mixtures can affect the frequency of resistance to ALS-inhibitors (FOR) in giant ragweed populations, this study evaluated the selection pressure for resistance exerted by preemergence (PRE) herbicide applications in traited soybean. Research was conducted in 2018 at two locations, each having either a low or high initial FOR. At the low-FOR location, a single PRE application of cloransulam alone or combined with S-metolachlor, metribuzin, or sulfentrazone resulted in an FOR of between 86 and 98% at 21 days after planting (DAP), an increase of 71% or greater beyond the nontreated control. Mixtures that included mesotrione + cloransulam or the commercial standard premix of flumioxazin + pyroxasulfone + chlorimuron resulted in less selection pressure (FOR < 55% and 60%, respectively), though FOR was still increased beyond the control. At 42 DAP, following a sequential postemergence application of glufosinate + S-metolachlor + fomesafen made at 21 DAP, the FOR had decreased in all treatments that also had a PRE application of cloransulam. After this sequential application, treatments that included mesotrione + cloransulam applied PRE had a FOR similar to that of the control, but the FOR remained elevated in all treatments without mesotrione. At the high-FOR location, no meaningful trends were observed regarding differential selection pressure resultant of herbicide mixtures or sequential applications. The FOR has been reported to be greater than 60% in half of Indiana fields infested with giant ragweed, which is similar to the initial frequency of 79% at the high-FOR location. Continued use of ALS-inhibitors is known to result in significant selection pressure for resistance, though this data clearly demonstrates that the inclusion of additional effective herbicide modes of action like mesotrione, coupled with sequential herbicide applications, can prolong the efficacy of cloransulam for control of giant ragweed. However, these tactics may be limited to geographies where giant ragweed populations are still predominately susceptible to ALS-inhibiting herbicides.

†Multiple Herbicide-Resistant Palmer Amaranth from Long-Term Conservation Tillage Plot in Kansas- What Options are Left? Chandrima Shyam*, Ednaldo A. Borgato, Dallas E. Peterson, Mithila Jugulam; Kansas State University, Manhattan, KS (145)

ABSTRACT

The evolution of multiple herbicide resistance in Palmer amaranth (*Amaranthus palmeri* S. Watson) is a major challenge for its management. The objective of this study was to identify and characterize possible evolution of multiple-herbicide resistance in a population of Palmer amaranth from a long-term conservation tillage field (KCTR= Kansas Conservation Tillage resistant) that was initially suspected of have evolved 2,4-D resistance. Seed from ten putative resistant plants that survived the application of 2,4-D at 560 g ae ha^{-1} (recommended field rate) were collected in summer 2018 and planted. Ten-12cm tall seedlings of KCTR (n=50) along with two susceptible populations (KSS=Kansas susceptible; MSS= Mississippi susceptible) were sprayed with recommended field rate of herbicides belonging to various site of action groups including synthetic auxins, acetolactate synthase (ALS)-, Photosystem II (PS-II)-, 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS)-, glutamine synthetase-, protoporphyrinogen oxidase (PPO)-, Photosystem I (PS-I)-, 4-Hydroxyphenylpyruvate dioxygenase (HPPD)- inhibitors and a combinations of PS-II- and HPPD-inhibitors. Additionally, KCTR plants were also evaluated for target-site resistance mechanisms to ALS-, PS-II-, and EPSPS-inhibitors. The results suggest that the KCTR population has evolved resistance to all the above herbicides except PS-I and glutamine synthetase-inhibitors. The survival rates of KCTR were 84% to 2,4-D, 34-60% to chlorsulfuron and thifensulfuron-methyl, 28% to glyphosate, 36-100% to metribuzin and atrazine, 29-84% to fomesafen and lactofen, and 84-90% to tembotrione or mesotrione. KCTR plants also survived commercial mix of pyrasulfotole and bromoxynil by 98%; however, showed sensitivity to tank mix of atrazine and mesotrione. KCTR plants that survived chlorsulfuron or atrazine application did not show any previously reported mutations, respectively, in the *ALS* or *PsbA* genes, the target sites of these herbicides, indicating the involvement of non-target site resistance mechanisms. Quantitative PCR analyses showed amplification of up to 26-79 *EPSPS* gene copies in plants that survived glyphosate application compared to KSS and MSS. In conclusion, KCTR population has evolved resistance to at least six commonly used herbicide modes of action leaving limited options for its management.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

†Reduced Glyphosate Translocation as a Novel Resistance Mechanism in *Bassia scoparia*. Neeta Soni*, Sarah Morran, Margaret Fleming, Franck Dayan, Todd Gaines; Colorado State University, Fort Collins, CO (146)

ABSTRACT

Glyphosate has been a very effective to control *Bassia scoparia* (L.) A. J. Scott. which is one of the most troublesome annual weeds in agricultural fields. However, due to an increase in selection pressure in *B. scoparia* populations, several cases of evolved resistance to glyphosate have been reported. Previous research reported EPSPS gene amplification as the mechanism that confers glyphosate resistance in *B. scoparia*. Target site mutations and non-target site mechanisms have been reported in other weed species but not yet in *B. scoparia*. From a field survey in sugar beet we identified a population of *B. scoparia* (P8) that showed a reduction in glyphosate sensitivity without increased EPSPS gene copy number and target site mutations. Based on this evidence, we hypothesized that P8 has evolved a different resistance mechanism. Our main objective was to identify and characterize the mechanism conferring reduced glyphosate susceptibility in the P8 population. We conducted metabolism, absorption, and translocation experiments to compare P8 with known glyphosate-susceptible and resistant *B. scoparia* populations. Glyphosate metabolite AMPA was not different across populations. The absorption and translocation experiments were conducted using radiolabel [14C]-glyphosate. Results from these experiments showed that P8 had a reduced glyphosate translocation trend compared to the susceptible and resistant populations. In order to further investigate the molecular basis of this trait it was necessary to originate a more homogeneous population. We developed a non-radiolabel screening method to identify and self-pollinate the plants that showed low glyphosate translocation. Currently we selected two P8 progenies that showed to translocate about 5% of the total absorbed glyphosate. These plants will be crossed with a susceptible biotype to derive a F2. Genotype-by-sequencing approach will be used to map the locus related to this mechanism. Understanding the additional glyphosate resistance mechanism could lead to the development of markers for early detection of resistance in other *B. scoparia* populations or commercial traits for tolerant crops.

†Amplification of Multiple Genes Along with EPSPS in Glyphosate-Resistant Common Waterhemp (*Amaranthus tuberculatus*). Balaji Aravindhan Pandian*, Sathishraj Rajendran, Sanzhen Liu, Venkatesh P. Ranganath, Vara Prasad P.V., Mithila Jugulam; Kansas State University, Manhattan, KS (147)

ABSTRACT

Common waterhemp (*Amaranthus tuberculatus*) is a problem weed in the Midwestern United States which can cause significant yield loss in major crops such as corn, and soybean. A common waterhemp population from Kansas conferred a high level of resistance to glyphosate as a result of amplification of *EPSPS* gene, the molecular target of glyphosate. The objective of this study was to sequence the whole genome of glyphosate-resistant and -susceptible individuals of common waterhemp to confirm the exact genomic copies of the *EPSPS gene* and also evaluate if any other genes along with *EPSPS* are also amplified. Three common waterhemp plants with different *EPSPS* copies determined by qPCR were classified as highly-(HR), moderately-(MR), and low-resistant (LR) to glyphosate along with a susceptible (S) were selected for this study. Genomic DNA was extracted from in all the four plants and sequenced using Illumina HiSeq2500. The whole-genome sequence of all the four samples were aligned to *Amaranthus hypochondriacus* reference genome. Gene copy number variation of glyphosate-resistant plants was calculated relative to the read count of the susceptible plant. The analysis of the data suggests that the *EPSPS* gene copy numbers determined by whole-genome sequencing is similar to that as determined by qPCR. However, multiple genes flanking *EPSPS* have also been found amplified along with *EPSPS* in HR sample while only *Transketolase* (*TKT*) gene, located close to the *EPSPS* was amplified in LR and MR plants. Multiple gene amplification patterns identified by whole-genome sequence analysis was validated in fifty glyphosate-resistant common watehemp plants using qPCR. These results also confirmed single and multi-gene amplification in common waterhemp. Therefore, co-amplification of multiple genes appears to have associated with the evolution of glyphosate resistance via *EPSPS* amplification in common waterhemp.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

Trifluralin Resistance and a Helical Growth Phenotype in Annual Ryegrass. Jinyi Chen*[1], Stephen Powles[2], Heping Han[2], Danica Goggin[2], Geoffrey Wasteneys[3], Eric L. Patterson[1], Qin Yu[2]; [1]Michigan State University, East Lansing, MI, [2]University of Western Australia, Perth, Australia, [3]University of British Columbia, Vancouver, BC (148)

ABSTRACT

Lolium rigidum Gaudin (annual ryegrass) is one of agriculture's worst weeds and is the cause of tremendous economic loss. Dinitroaniline herbicides (trifluralin, pendimethalin etc.) have been used extensively and effectively as pre-emergence herbicides for annual ryegrass management since 1960s; however, the recurrent application of a single herbicide for decades has resulted in the selection of dinitroaniline resistance in annual ryegrass. The genetic mechanisms underpinning dinitroaniline resistance remain unknown. Dinitroaniline-resistance was characterized in one annual ryegrass population by dose-response curves. This population had high trifluralin resistance (32-fold compared with a susceptible population) and cross-resistance to other dinitroaniline herbicides. To determine the genetic cause of resistance, both target-site resistance (TSR) and non-target-site resistance (NTSR) mechanisms were investigated. We sequenced the α-tubulin gene from the resistant and susceptible plants and discovered mutations related with dinitroaniline-resistance. Several α-tubulin mutations, including Val-202-Phe, Thr-239-Ile, Arg-243-Lys and Arg-243-Met, were confirmed to confer dinitroaniline resistance in transgenic rice tissue culture. Val-202-Phe and Arg-243-Lys/Met are novel mutations first found in annual ryegrass. For NTSR, uptake, translocation and metabolism of trifluralin were measured in susceptible and resistant populations using [^{14}C]-trifluralin. We found no differences in uptake or translocation between the resistant and susceptible plants; however, we were able to detect enhanced trifluralin metabolism in all the four resistant populations tested. This result suggests that trifluralin metabolic resistance could be common in the field. Furthermore, plants homozygous for the Arg-243-Met α-tubulin mutation exhibited right-handed helical growth, severe dwarfism and considerable biomass reduction when compared with the susceptible plants. We hypothesize that the plant morphology alteration and dwarfism is due to the specific amino acid substitution at 243 residue in tubulin, which incurs a significant fitness penalty on resistant plants.

†Continuous Use of Herbicide Mixture Decreases *Echinochloa crus-galli* Control. Carlos Alberto G. Rigon*[1], Luan Cutti[2], Mateus Gallon[2], Walker Schaidhauer[2], Todd Gaines[1], Aldo Merotto Jr[2]; [1]Colorado State University, Fort Collins, CO, [2]Federal University of Rio Grande do Sul, Porto Alegre, Brazil (149)

ABSTRACT

Herbicide mixture is used to increase the spectrum of weed control and to prevent or manage target-site resistance to the components of the mixture. However, there is no information on the effect of mixtures, especially at low doses, on the evolution of herbicide resistance. The objective of this study was to evaluate the effect of low dose of fenoxaprop-p-ethyl and imazethapyr mixture on the evolution of resistance caused by metabolism in *Echinochloa crus-galli* (L.). The biotypes used were MOST (susceptible to fenoxaprop and imazethapyr) and CAMAQ (resistant to imazethapyr by enhanced metabolism). Initially, experiments were performed to determine the minimum doses of control to herbicides fenoxaprop (FE) and imazethapyr (IMA) isolated and in mixture (MIX). After that, plant selection experiments were performed through the low doses of each isolated herbicide and in mixture. Surviving plants at maximum doses were multiplied for two selection cycles. Dose-response curves were carry out for FE, IMA and MIX with the parental lines (G0), plants of generation two not selected by any herbicide (G2 unselected) and plants of generation two selected with fenoxaprop (G2FE), imazethapyr (G2IMA) and mixture (G2MIX) to verify some decrease in susceptibility. The G2FE, G2IMA and G2MIX selected plants were evaluated for herbicide effect of other mechanisms of action not used in the recurrent selection. Expression analysis on eight cytochrome P450 genes (CYPs) and one glutathione-S-transferase (GST) gene were performed by RT-qPCR in G0, G2 unselected, G2FE, G2IMI and G2MIX plants before and after application of the herbicides. The selection of barnyardgrass with MIX at low doses provided higher survival in progenies, mainly on CAMAQ biotype, compared to G0 plants. The resistance factors (RF) for G2MIX plants of MOST and CAMAQ were 1.6 and 3.1, respectively, in relation to G0 after application of MIX. Selection with low doses of the herbicide FE alone provided a decrease in progeny control of both studied biotypes. Recurrent selection with low doses of IMA did not cause any change in herbicide sensitivity. G2FE and G2MIX plants were less sensitivity to quinclorac in relation to G0 plants. G2FE and G2MIX plants of CAMAQ biotype resulted in RF of 4.8 and 3.5, respectively, after quinclorac application. These RFs were reduced to 1.7 due previous application of P450 inhibitor malathion. The gene *CYP81A22* was up regulated by 3.1- and 4.6-fold change in G2MIX of MOST and CAMAQ to G0, respectively. The genes *CYP71AK2*, *CYP72A254*, *CYP72A258*, *CYP81A14* e *CYP81A21* were up regulated in G2FE of MOST or CAMAQ after FE application. The recurrent selection with IMA did not change the expression of the studied genes. The decreased control in the G2MIX plants is mostly due to selection from fenoxaprop rather than imazethapyr in the mixture. The fenoxaprop has greater role to up regulate the genes than imazethapyr. CAMAQ biotype was more prone to involve resistance to other herbicides with different mechanism of action. The continuous use of fenoxaprop and imazethapyr mixture in low doses may favor the evolution of resistance to these and other herbicides, especially in plants with resistance associated with increased metabolism.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

The Mechanism of Glyphosate Resistance via Transposon-Mediated *EPSPS* Tandem Gene Duplication in *K. scoparia*. Eric L. Patterson*[1], Todd Gaines[2], Chris A. Saski[3], Daniel B. Sloan[2], Patrick J. Tranel[4], Philip Westra[2]; [1]Michigan State University, East Lansing, MI, [2]Colorado State University, Fort Collins, CO, [3]Clemson University, Clemson, SC, [4]University of Illinois, Urbana, IL (150)

ABSTRACT

Increased copy number of the 5-enolpyruvylshikimate-3-phosphate synthase (*EPSPS*) gene confers resistance to glyphosate, the world's most-used herbicide. There are typically three to eight *EPSPS* copies arranged in tandem in glyphosate-resistant populations of the weed kochia (*Kochia scoparia*). Here, we report a draft genome assembly from a glyphosate-susceptible kochia individual. Additionally, we assembled the *EPSPS* locus from a glyphosate-resistant kochia plant by sequencing select bacterial artificial chromosomes from a kochia bacterial artificial chromosome library. Comparing the resistant and susceptible *EPSPS* locus allowed us to reconstruct the history of duplication in the structurally complex *EPSPS* locus and uncover the genes that are coduplicated with *EPSPS*, several of which have a corresponding change in transcription. The comparison between the susceptible and resistant assemblies revealed two dominant repeat types. Additionally, we discovered a mobile genetic element with a FHY3/FAR1-like gene predicted in its sequence that is associated with the duplicated *EPSPS* gene copies in the resistant line. We present a hypothetical model based on unequal crossing over that implicates this mobile element as responsible for the origin of the *EPSPS* gene duplication event and the evolution of herbicide resistance in this system. These findings add to our understanding of stress resistance evolution and provide an example of rapid resistance evolution to high levels of environmental stress.

Enhanced Metabolism Confers Resistance to *S*-Metolachlor in Two Illinois Waterhemp (*Amaranthus tuberculatus*) Populations. Seth Strom*, Nicholas J. Seiter, Adam Davis, Aaron G. Hager, Dean E. Riechers; University of Illinois, Urbana, IL (151)

ABSTRACT

Since its commercialization in the 1990s, *S*-metolachlor has been widely used preemergence (PRE) in crops such as corn, soybean, and cotton to control annual grasses and small-seeded dicot weed species, such as waterhemp (*Amaranthus tuberculatus*). Previously, we reported two multiple herbicide-resistant (MHR) waterhemp populations (MCR and CHR) from Illinois were not controlled with *S*-metolachlor under field conditions. Greenhouse dose-response experiments with *S*-metolachlor supported field observations and generated R/S ratios ranging from 18–64 fold compared with two sensitive populations. We hypothesized that a physiological mechanism within the plant, such as enhanced herbicide metabolism, was responsible for the reduced efficacy of *S*-metolachlor. Radiolabeled *S*-metolachlor was utilized to investigate herbicide metabolism in seedlings from the CHR and MCR populations in comparison to sensitive waterhemp (WUS and ACR) populations and corn. Thin-layer chromatography (TLC) experiments revealed that CHR and MCR seedlings metabolized *S*-metolachlor faster than either sensitive population between 2–24 hours after treatment. High-performance liquid chromatography (HPLC) experiments determined the times to degrade 50% (DT_{50}) and 90% (DT_{90}) of parent *S*-metolachlor in CHR and MCR were shorter than either sensitive waterhemp population but equal to corn. The calculated DT_{90} values for CHR, MCR, and corn are 3.2, 2.7, and 2.7 hours, respectively. In contrast, more than six hours were required for either WUS or ACR to metabolize 90% of the parent herbicide. TLC and HPLC experiments also revealed that metabolite profiles in CHR and MCR differ from sensitive waterhemp or corn. The current corroboration of field, greenhouse, and laboratory experiments suggests CHR and MCR have evolved metabolic resistance to *S*-metolachlor. Research is underway to further quantify and identify initial metabolites formed and investigate the putative enzyme(s) and metabolic pathway(s) involved in *S*-metolachlor detoxification in waterhemp.

†Identification of *Triticum aestivum C*hromosomes Possessing Genes that Confer Natural Tolerance to Halauxifen-Methyl. Olivia A. Obenland*, Frederic L. Kolb, German A. Bollero, Dean E. Riechers; University of Illinois, Urbana, IL (152)

ABSTRACT

Synthetic auxin herbicides selectively control dicot weeds in cereal crops, which possess natural tolerance to these herbicides. Natural tolerance in hexaploid bread wheat (*Triticum aestivum*; 2n = 6x = 42; AABBDD) is primarily due to rapid and irreversible herbicide detoxification. However, specific genes encoding enzymes that detoxify synthetic auxin herbicides in wheat have yet to be identified. Our objective was to identify wheat chromosomes that possess genes encoding enzymes that detoxify halauxifen-methyl (HM), a postemergence (POST) wheat-selective herbicide, using wheat substitution and aneuploid lines. In order to accomplish this objective, seedlings with 1-2 leaves (Zadoks stages 11-12) were treated with two POST rates of HM in the greenhouse. Each of the 21 substitution lines has one chromosome removed and substituted with the homoeologous chromosome from the wild diploid wheat species, *Aegilops searsii* (S genome), which is sensitive to HM. This approach allowed for identification of wheat chromosomes possessing genes associated with HM tolerance because only the substitution lines lacking these chromosomes displayed sensitivity to HM. Furthermore, the locations of these genes were narrowed down to specific homoeologous chromosomes with nullisomic-tetrasomic (NT) lines, which are lines that lack one homoeolog pair but have additional copies other homoeologs. In alien substitution lines where 5S was substituted for 5A or 5B the greatest losses of HM tolerance were observed with biomass reductions reaching approximately 40% or more, suggesting these chromosomes possess genes associated with HM detoxification. Additional experiments with NT lines also revealed genes associated with HM tolerance are likely present on chromosomes 5A and 5B; however, the genes on 5A appear to play a larger role since the N5A-T5D line displayed the greatest sensitivity to HM (approximately 55% biomass reduction). Genes located on 5A and 5B may govern tolerance to HM as well as tolerance to other wheat-selective herbicides, such as ALS or ACCase inhibitors. Additionally, candidate HM tolerance genes on chromosomes 5A/B will be identified through RNAseq or proteomic analysis and functionally characterized in future research.

Transcriptome Analysis of Fluroxypyr-Resistant *Bassia scoparia*. Olivia E. Todd*, Todd Gaines, Eric P. Westra, Philip Westra; Colorado State University, Fort Collins, CO (153)

ABSTRACT

Bassia scoparia (kochia) is a troublesome weed of open space and agronomic crops. The synthetic auxin fluroxypyr has been used to control kochia in fallow, cereals and range. In 2014, a line isolated from eastern Colorado was found to be fluroxypyr resistant. We investigate the underlying resistance mechanisms in fluroxypyr resistant kochia with an RNA seq experiment with timepoints before treatment, 3 hours after treatment (HAT) and 10 HAT. We used one fluroxypyr resistant line (Flur-R) and two susceptible lines of varying backgrounds (9425-S and J01-S). We explored differences in gene expression using the DEseq2 pipeline as well as sequence variation using a novel pipeline. Differential expression was examined in major auxin signaling genes: Aux/IAA repressors, Auxin Response Factors (ARFs), Transport-inhibitor-response-1 (TIR1), auxin induced 1-Aminocyclopropane -1-Carboxylic Synthase (ACS), auxin efflux transporters (PINs) and several of these proteins for sequence variants that may affect function. We report upregulation of several Aux/IAAs in both resistant and susceptible kochia lines after treatment (Flur-R and 9425-S), and one Aux/IAA was constitutively up-regulated in Flur-R. ARF19, a key protein in auxin signaling, was upregulated in both lines, however, the other expected protein, ARF7 was not upregulated or constitutively expressed in the Flur-R, but was upregulated in 9425-S. One auxin efflux protein (PIN) was found to be constitutively up-regulated in Flur-R. Additional data analysis and candidate gene validation are needed to reach a definitive conclusion regarding the fluroxypyr resistance mechanism in this line of kochia.

Symposium: Using RStudio for Visualization and Analysis of Weed Science Experiments

Abstracts were not requested for symposia and were submitted on a voluntary basis. The following presentations did not submit an abstract:

Basics of R and RStudio. Ethann R. Barnes*[1], Erin Burns[2], Maxwel C. Oliveira[3], John A. Schramski[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Michigan State University, East Lansing, MI, [3]University of Wisconsin-Madison, Madison, WI (154)

Data Wrangling with Dplyr. Maxwel C. Oliveira*; University of Wisconsin-Madison, Madison, WI (155)

An Introduction to Using R for Weed Population Dynamics Modeling. Erin Burns*; Michigan State University, East Lansing, MI (156)

Using Drc Package for Dose Response and Critical Period Analysis. Stevan Z. Knezevic*[1], Ethann R. Barnes[1], Maxwel C. Oliveira[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Wisconsin-Madison, Madison, WI (157)

Using Ggplot2 for Plotting Drc Models and Dose Response Data. Ethann R. Barnes*; University of Nebraska-Lincoln, Lincoln, NE (158)

Creating Reproducible Reports Using R Markdown. Maxwel C. Oliveira*; University of Wisconsin-Madison, Madison, WI (159)

R Help Session - Bring Your Questions and Coding Troubles. Ethann R. Barnes*[1], Erin Burns[2], Stevan Z. Knezevic[1], Maxwel C. Oliveira[3], John A. Schramski[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Michigan State University, East Lansing, MI, [3]University of Wisconsin-Madison, Madison, WI (160)

Symposium: Cover Crops: An Ecological Tool for Weed Management

Abstracts were not requested for symposia and were submitted on a voluntary basis. The following presentations did not submit an abstract:

Growers' Feedback on the Use of Cover Crops for Weed Management in Nebraska. Maxwel C. Oliveira*; University of Wisconsin-Madison, Madison, WI (161)

Integrating Cover Crops and Herbicide Programs: Challenges and Opportunities in the Northeast. John Wallace*; Penn State, University Park, PA (163)

Panel Discussion. Cover Crops: An Ecological Tool for Weed Management. J. Anita Dille*[1], John Wallace[2], Erin Haramoto[3], Maxwel C. Oliveira[4], O. Adewale Osipitan[5]; [1]Kansas State University, Manhattan, KS, [2]Penn State, University Park, PA, [3]University of Kentucky, Lexington, KY, [4]University of Wisconsin-Madison, Madison, WI, [5]University of California-Davis, Davis, CA (165)

Cover Crop Management and Influences on Winter and Summer Weed Suppression. Erin Haramoto*; University of Kentucky, Lexington, KY (162)

ABSTRACT

Producers adopt cover crops for many reasons, and weed suppression may be a benefit that can improve their short-term economic profitability. While growing, cover crops modify the soil environment to reduce weed germination and establishment and outcompete weeds that do successfully emerge. Cover crop residue (after termination) also influences the soil environment, typically reducing weed seed germination and thus seedling emergence and establishment in the subsequent cash crop; residues may also reduce weed growth depending on resource availability. The goals of using cover crops for weed management in herbicide-based systems is to (1) reduce weed density, resulting in fewer weeds to be killed with an herbicide; (2) reduce size of weeds that do establish through competition for resources, resulting in more effective herbicide applications; and (3) delay weed emergence, allowing longer windows for effective POST control. Our research program investigates cover crop management to maximize these services, as well as weed response to different cover cropping scenarios. Kentucky's corn/soybean producers tend to utilize fall-planted cereal rye or wheat cover crops and these small grains can be very effective for winter and summer weed management. Factors that can maximize cover crop based suppression of winter weeds include early and maximal ground cover to suppress germination of light-sensitive weed seeds and greater biomass production to maximize competitive potential against weeds that do emerge. Our research shows higher seeding rates (112 vs. 34 kg seed ha^{-1}) of cereal rye or wheat did not consistently result in more aboveground cover crop biomass by termination in the spring, likely because of plant tillering. As a result, increasing the cover crop seeding rate did not always reduce winter weed biomass. However, higher seeding rates did result in more ground cover, which could result in improved suppression of light-sensitive species. Earlier cover crop seeding dates resulted in more fall biomass production, but often did not result in less weed biomass in part due to continued summer annual weed establishment. In Kentucky, differences in fall biomass were not apparent by the spring, suggesting that the spring period is key for cover crop biomass production in warmer areas. For summer weed management, our research focuses on moderate amounts of cover crop residue and integrates herbicides. We have shown that (1) soil residual herbicides used in tobacco do not influence establishment or growth of cereal rye, wheat, or crimson clover when they are sown the fall following application; (2) weed density in no-till tobacco varied between different amounts of cover crop residue, but was not influenced by cover crop species selection; and (3) in an herbicide-based soybean system, there is a negative, albeit weak relationship between cover crop biomass (2-4000 lbs A^{-1}) and summer weed density. Our research shows that cover crops and their residues are not automatically weed-suppressive, and that management is an important component in improving their ability to provide this important ecosystem service.

Quantitative Summary of Weed Suppression Benefits of Cover Crops Using A Meta-Analysis. O. Adewale Osipitan*; University of California-Davis, Davis, CA (164)

ABSTRACT

The contrasting results among studies that reported weed suppression provided by cover crops in cropping systems, suggest a need for comprehensive quantitative review of these studies. Systematic review and meta-analysis are methods that have been widely used for quantitative research reviews. Systematic reviews ensure that a comprehensive survey of primary studies occurred, with a goal of reducing bias by appraising and synthesizing the surveyed studies based on a set of criteria to answer a review question. Data extracted through a systematic review are summarized into single quantitative estimates or effect sizes by a statistical technique known as meta-analysis. These review methods can be beneficial because they rely on quantitative information and allow for testing of hypotheses that cannot be satisfactorily answered by a single primary study. Using meta-analysis, we have previously provided quantitative summaries of weed suppression benefits of cover crops and factors that may influence these benefits, by utilizing analytic tools such as mean difference and response ratio. Overall, our meta-analysis results indicated that cover crops provided weed suppression comparable to those provided by chemical and mechanical weed control methods, particularly at early part of the growing season in different cropping systems. In addition, the meta-analysis showed that cover crop could provide a range of weed suppression depending on management decisions such as choice of cover crop species, cover crop sowing season, sowing dates within seasons, seeding rate, termination date, delay in main crop planting date after cover crop termination, tillage system under which cover crop was produced, and integrating cover crop with other weed control inputs.

Papers: Agronomic Crops II – Soybeans

†Fall-Seeded Cereal Cover Crops Suppress Horseweed in No-Tillage Soybean. John A. Schramski*, Christy Sprague, Karen Renner; Michigan State University, East Lansing, MI (166)

ABSTRACT

Integrating fall-planted cover crops as an additional management strategy to control herbicide-resistant horseweed (*Erigeron canadensis* L.) may reduce the reliance on herbicides and slow the evolution of resistance to currently effective herbicides. Michigan's short cover crop planting window following cash crop harvest makes establishment and spring cover crop biomass accumulation for weed suppression challenging. Field experiments were conducted in three site-years to investigate the effects of fall-planted cereal cover crops terminated at different timings to manage herbicide-resistant horseweed. The experiment was a split-split-plot design with main plots of cereal rye and winter wheat drilled at two different seeding rates (67 and 135 kg ha^{-1}) and a no cover control established the fall prior. Within each cover crop main plot two herbicide subplots were established that included cover crop termination treatments of glyphosate one week prior to ("early termination") and one week after ("planting green") planting dicamba-resistant soybean. Dicamba was applied postemergence (POST) six weeks after planting to half of the plots, while the other half did not receive a POST. Horseweed emergence primarily occurred during the spring and continued the remainder of the season in all site-years. Early terminated cereal rye averaged over seeding rate produced 1,546 kg ha^{-1} dry biomass in two out of three site-years. Cereal rye biomass was two to three times greater than biomass of winter wheat. Ground cover was 58 and 47% for cereal rye and winter wheat, respectively. Delaying termination by planting green increased cereal rye and winter wheat biomass production to 4,883 and 2,913 kg ha^{-1}, respectively. Planting green terminated cover crops provided 15% more ground cover compared with early terminated cover crops when measured at VE soybean. Cover crops did not consistently reduce horseweed density compared with the no cover control; however, horseweed biomass was reduced by 82 and 66% when planting green and terminated early, respectively. Horseweed biomass was not affected by cover seeding rate or species when terminated early, but cereal rye provided 9% more horseweed biomass reduction when planted green. At the time of POST herbicide application, horseweed biomass was reduced 88 and 24% when terminated at the planting green and early timings, respectively. At this time, high cover crop seeding rates reduced horseweed biomass more than low seeding rates. Soybean yield did not differ by cover seeding rate or species. All covers yielded greater than no cover when planted green, regardless of POST herbicide application. Soybean yields were two times greater in planting green treatments compared with the early termination treatments in absence of a POST and when cover biomass was limited. In conclusion, fall-seeded cereal cover crops provided horseweed suppression compared with no cover until POST application. Delaying cover termination by planting green produced higher cover biomass, reduced horseweed biomass, and improved soybean yields compared to early terminated covers. Utilizing fall-seeded cereal cover crops could improve early season horseweed control and reduce reliance on herbicides.

†Glyphosate Alternatives for Cereal Rye Termination with Different Application Timings in Soybean. Jose H. Scarparo de Sanctis*[1], Vipan Kumar[2], Stevan Z. Knezevic[1], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Kansas State University, Hays, KS (167)

ABSTRACT

Cover crops can provide many benefits for the agricultural systems including erosion control, increased nutrient efficiency, greater soil health, reduce soil compaction, and also provide weed control. However, the misuse of this technology can greatly reduce cash crop yields. In Nebraska, the most commonly used cover crop is cereal rye (*Secale cereale* L.). Its increased popularity in soybean cropping systems requires better understanding of termination timings and effective herbicide terminations programs. Glyphosate application is currently the most common termination method, but alternative herbicides programs for terminating cereal rye are not well documented. Therefore, a field study was conducted in 2019 in the South-Central Agricultural Laboratory in Clay County, Nebraska to determine alternative termination herbicide programs in cereal rye at different termination timings. Treatments consisted of clethodim (135.8 g ai ha^{-1}), fluazifop-P (140 g ai ha^{-1}), quizalofop (61.6 g ai ha^{-1}), fluazifop-P / fenoxaprop (140 g ai ha^{-1} + 39.2 g ai ha^{-1}), and glyphosate (1260 g ai ha^{-1}) applied at three different timings (15 days before planting, soybean planting date, and 15 days after planting soybean). Visual estimations of control were collected weekly until POST emergence applications. At 15 DAT aboveground biomass was collected for cereal rye plants dried at 65°C until constant weight. In addition, soybean stand and yield was collected to investigate potential negative impacts from the different termination timings. Data was subjected to ANOVA in R utilizing the *Agricolae* package. Most herbicides resulted in similar cereal rye control compared to glyphosate for all the termination timings. Glyphosate resulted in >96% control of cereal rye for all the termination timings. Conversely, clethodim resulted in 77.5, 66, and 28% control of cereal rye at 15 days before planting, planting, and 15 days after planting, respectively.

*Presenting Author

†Paper or poster in the graduate and/or undergraduate student contest

†Does Ammonium Thiosulfate (ATS) Antagonize Glyphosate for Spring Burndown Applications? Marcelo Zimmer*, Julie M. Young, Bryan G. Young, William G. Johnson; Purdue University, West Lafayette, IN (168)

ABSTRACT

Sulfur (S) is an essential secondary macronutrient for plant development and to reach crop yield potential. Recently, symptoms of S deficiency have been observed in corn, soybean, and alfalfa fields in the Midwest. Several factors may be contributing to the increasing frequency of S deficiency, including reduced atmospheric deposition of S through rainfall, increased adoption of no-till systems, and high amounts of crop residue. Research showed that supplying S preplant at rates of 16.8 to 28.0 kg ha^{-1} in S deficient soils may increase yield by as much as 870 kg ha^{-1} for soybeans and 1380 kg ha^{-1} for corn. Ammonium thiosulfate (ATS) with the formula $(NH_4)_2S_2O_3$ is a low cost inorganic source of S that can be applied preplant. Custom applicators and farmers have shown interest in applying ATS tank-mixed with burndown herbicide treatments such as glyphosate and glyphosate plus 2,4-D to reduce application costs. However, concerns have been raised about potential antagonistic effects of ATS with burndown herbicides. Greenhouse experiments were conducted to evaluate efficacy of glyphosate (0.86 kg ae ha^{-1}) and glyphosate plus 2,4-D (0.53 g ae ha^{-1}) treatments on wheat (*Triticum aestivum* L.), velvetleaf (*Abutilon theophrasti* Medik.), and common lambsquarters (*Chenopodium album* L.) with the addition of two ATS rates equivalent to 4.8 and 22.4 kg ha^{-1} of S. Treatments were applied with and without dry ammonium sulfate (AMS) at 1.43 kg ha^{-1} to evaluate the influence of AMS on any antagonistic effects of ATS. Herbicide treatments containing glyphosate alone or glyphosate plus AMS resulted in greater wheat control 14 days after treatment (DAT) (97 to 99% control) than treatments containing glyphosate plus ATS and/or 2,4-D (67 to 83% control), except glyphosate plus 2,4-D plus AMS (86% control). Therefore, adding ATS reduced wheat control at 14 DAT and the addition of AMS did not improve wheat control on treatments that contained ATS. All treatments containing glyphosate plus 2,4-D and the glyphosate plus AMS treatment resulted in greater velvetleaf control 14 DAT (97 to 100% control) than glyphosate plus ATS treatments or glyphosate alone (89 to 93% control). The inclusion of 2,4-D to any treatment resulted in greater common lambsquarters control at 14 DAT (89 to 92% control) than all other treatments (67 to 74% control). ATS did not affect herbicide efficacy on common lambsquarters. The phytotoxic response of common lambsquarters to ATS appeared to balance out any potential antagonistic effect of this fertilizer on glyphosate efficacy. Additionally, none of the glyphosate treatments without 2,4-D resulted in adequate common lambsquarters control ($\geq$ 90%) in the greenhouse. Data analysis of fresh biomass resulted in similar trends to visual control ratings. In conclusion, ATS has the potential to antagonize burndown herbicide treatments such as glyphosate and glyphosate plus 2,4-D, especially on grass weed species such as wheat. Broadleaf weeds species may respond differently to the addition of ATS. Experiments at the field level and further research looking into additional herbicide programs and weed species is necessary to further understand the potential antagonistic effects of ATS on herbicide efficacy.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

†Influence of PRE-Emergence Herbicides on Soybean Nodulation and Nitrogen Fixation. Victor Hugo Vidal Ribeiro*[1], Lucas Silva Gontijo Maia[1], Nicholas J. Arneson[1], Jean-Michel Ané[1], Jose Barbosa dos Santos[2], Rodrigo Werle[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Federal University of Jequetinhonha and Mucuri, Diamantina, Brazil (169)

ABSTRACT

The use of PRE-emergence herbicides is a common practice for early-season weed control in soybean production. The influence of preemergence (PRE) herbicides on soybean-microorganism interaction is not well understood. The objective of this study was to investigate the influence of several PRE herbicides on soybean development, *Rhizobium* nodulation, and nitrogen fixation. The greenhouse experiment was conducted at the University of Wisconsin-Madison, in a RCBD (4 replications) and replicated twice. The soil used to conduct a study was silt loam (16% sand, 61% silt and 23% clay) with pH of 6.9 and 6.4% organic matter. Herbicide treatments consisted of labeled field rate of imazethapyr, chlorimuron, cloransulam, metribuzin, sulfentrazone, flumiozaxin, saflufenacil, acetochlor, S-metolachlor, dimethenamid, pyroxasulfone, and a nontreated control. Soybean seeds were inoculated with *Bradyrhizobium japonicum* and planted in 10,000 cm^3 pots filled with field soil. Soybean canopy was assessed early-season (VC growth stage); soybean biomass, number of nodules, nodule viability, nodule diameter, nodule biomass and nitrogenase activity were assessed at R2 stage. Soybean growth at VC stage was slightly affected by sulfentrazone. The PRE-emergence herbicides tested herein had no impact on soybean biomass, number of nodules, nodule viability, nodule diameter, nodule biomass and nitrogenase activity at the R2 stage. Though PRE-emergence herbicides may slightly affect early-season soybean development, negligible impacts on plant development, soybean nodulation and nitrogen fixation. Thus, when sprayed according to the label, the benefits of PRE-emergence herbicides for control of troublesome weed species very likely outweigh any potential concern regarding soybean nodulation, N fixation and growth.

†Weed Management Systems in XtendFlex Soybean. Adam L. Constine*, Christy Sprague; Michigan State University, East Lansing, MI (170)

ABSTRACT

Herbicide-resistant weeds continue to present a challenge for Midwest soybean growers. Current soybean technologies offer growers limited options for the management of multiple-resistant weeds such as common waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer) and horseweed (*Erigeron canadensis* L.). Newer soybean technology platforms, such as Bayer's new XtendFlex® soybean, provide growers the flexibility to use multiple effective herbicide sites of action (glyphosate, glufosinate, and dicamba-resistant) for herbicide-resistant weed control. In 2019, field experiments were conducted using the XtendFlex® soybean system to evaluate control of glyphosate-resistant common waterhemp and glyphosate-resistant horseweed in Shepherd and East Lansing, MI, respectively. Twenty different herbicide treatments were examined for common waterhemp control utilizing PRE followed by POST or EPOS followed by LPOS applications. Flumioxazin at 72 g ha^{-1} was the PRE herbicide used in this study. EPOS, POST, and LPOS applications included glyphosate (1.3 kg ae ha^{-1}), glufosinate (0.65 kg ha^{-1}), dicamba (0.56 kg ha^{-1}), acetochlor (1.3 kg ha^{-1}), and fomesafen (0.28 kg ha^{-1}) applied alone and in various combinations. Eighteen different herbicide treatments were examined for horseweed control in no-till soybean. Dicamba (0.56 kg ha^{-1}) + metribuzin (0.3 kg ha^{-1}) + glyphosate (1.3 kg ae ha^{-1}) or glyphosate alone applied 14 d prior to planting (EPP) were the base treatments prior to POST glyphosate (1.3 kg ae ha^{-1}), glufosinate (0.65 kg ha^{-1}), or dicamba (0.56 kg ha^{-1}) applied alone or in combinations. Additional treatments included comparisons with non-dicamba commercial burndown treatments and the use of other soil-applied herbicides. All PRE flumioxazin followed by POST treatments provided greater than 90% waterhemp control, except when glyphosate was applied POST (63%), 56 d after planting (DAP). In the two-pass POST system, treatments that utilized two effective herbicide sites of action or tank mixes of two effective sites of action provided greater than 90% waterhemp control, while treatments that utilized only one effective site of action provided 78-80% control. The two applications of glyphosate alone provided 40% control. Overall, waterhemp control was greater from the PRE followed by POST treatments compared with the 2-pass POST treatments, 56 DAP. However, by 70 DAP there were no differences between these systems. There were very few differences in horseweed control. Any treatment that contained glufosinate POST resulted in greater than 99%, 14 DAT and 28 DAT; glyphosate, dicamba, and glyphosate + dicamba provided 87-91% control 14 DAT and 91-96% control 28 DAT. From this first year of research, various herbicide programs used in XtendFlex® soybean prove to be effective in managing glyphosate-resistant waterhemp and horseweed.

†Systems Approach for Weed Control in Dicamba-Resistant Soybeans in Wisconsin. Sarah V. Striegel*, Maxwel C. Oliveira, Ryan DeWerff, Shawn Conley, David Stoltenberg, Rodrigo Werle; University of Wisconsin-Madison, Madison, WI, (171)

ABSTRACT

Soybeans are an important component of annual cropping systems in Wisconsin and throughout the North Central region. Weed interference can negatively impact crop yield; as the number of resistant weed populations continue to increase, many producers are interested in utilizing new herbicide-tolerant trait packages. Roundup Ready 2 Xtend (glyphosate- and dicamba-tolerant) is a novel option for enhancing control of herbicide-resistant broadleaf weeds post-emergence in soybeans. A field study was conducted as an a RCBD with 4 replications in Wisconsin at three sites in 2018 and four sites in 2019 to evaluate the efficacy of glyphosate + dicamba applied post-emergence in RR2Xtend soybeans at different developmental stages: V1-V2, V3-V4, and V5-V6/R1. The addition of acetochlor post-emergence as part of the glyphosate + dicamba treatment and its impact on overall weed control was also evaluated. Target species included *Ambrosia trifida, A. artemiisifolia,* and *Amaranthus tuberculatus*; however, weed species spectrum varied across sites. Satisfactory weed biomass reduction was attained for all pre- (flumioxazin) followed by post-emergence treatments, regardless of application timing. The application timing impacted weed biomass and crop yield at three out of seven site-years where the V3-V4 timing optimized both of these variables, whereas acetochlor post-emergence did not influence these variables. End-of-season target weed seed fecundity was reduced for the two pass programs in comparison with the nontreated control and pre-only treatments at all four site-years it was collected on. The findings of this study will help producers using Roundup Ready 2 Xtend technology in determining the best time to complete a post-emergence application given their weed species spectrum, the value of additional layered residual herbicide, the risks and benefits associated with the respective application timing, and how the use of this technology can help diversify their weed management programs.

†Role of Other Foliar Herbicide Applications on the Expression of Dicamba Injury. Matthew J. Osterholt*, Bryan G. Young; Purdue University, West Lafayette, IN (172)

ABSTRACT

A major concern with in-crop applications of dicamba to dicamba-resistant soybean (*Glycine max* (L.) Merr.) is the potential for off-target movement to sensitive crops. In 2017, an estimated 1.45 million hectares of soybean were injured by off-target dicamba movement in the United States. While several studies have been conducted to determine chemical and environmental influences on dicamba volatility, little research has investigated the dynamic between sensitive soybean and volatilized dicamba acid. Absorption of dicamba into soybean leaves can be limited without the benefit of surfactants. Therefore, a theory was developed that the use of spray applications that involve a surfactant on sensitive soybean may influence the extent of dicamba injury that develops following dicamba exposure. Thus, a field experiment was conducted to determine if herbicide treatments containing surfactants applied prior to or following dicamba exposure influence the response of dicamba-sensitive soybean. In order to simulate a dicamba exposure event, technical grade dicamba acid was dissolved in a 50/50 methanol to de-ionized water and applied to dicamba-sensitive soybean at the V5 growth stage at a dose associated with off-target movement (0.56 g ae ha^{-1}). Treatments were arranged as a two-factor factorial in a randomized complete block design with four replications. Factor A consisted of water and three different herbicide treatments containing surfactants in the commercial formulations of glyphosate, glyphosate and acetochlor, and glufosinate. All applications were applied at 140 L ha^{-1}. Factor B consisted of herbicide application timing (in relation to the dicamba acid exposure) which were 24 hours before, 30 min before, 30 minutes after, and 24 hours after. Across all evaluation timings, the herbicide treatments increased soybean injury in comparison to water averaged across all application timings. At 14 and 28 DAT, applications made 30 min before the dicamba exposure resulted in increased soybean injury in comparison to herbicide treatments made at 24 hours before and 24 hours after. All herbicide treatments decreased the average number of soybean nodes, the average width of the middle leaflet on the sixth trifoliate, and soybean height in comparison to water. These results suggest that the herbicide treatments containing surfactants applied prior to or following dicamba exposure can increase soybean response to dicamba. Future research that validates these results under a controlled environment and with a greater focus on surfactants and dicamba foliar absorption will be conducted.

†Response of Insect Pest and Beneficial Species to the Timing and Severity of Dicamba Injury in Soybean. William A. Tubbs*, Kevin Rice, Mandy Bish, Kevin Bradley; University of Missouri, Columbia, MO (173)

ABSTRACT

In recent years, off-target movement of dicamba has been one of the most significant issues to affect non-dicamba-resistant (DR) soybean production in the U.S. Although a variety of research has been conducted to determine the effects of off-target dicamba movement on soybean yield, few studies have been conducted to understand the effects that dicamba injury has on insect infestations in non-DR soybean. However, previous research has shown drift-level doses of dicamba in alfalfa leads to decreased visitation from pollinator species. Field experiments were conducted at four locations in Missouri in 2018 and three locations in 2019 to determine if dicamba injury to non-DR soybean has any effect on the prevalence and severity of insect pest and beneficial species throughout the growing season. At each location, all herbicide treatments were applied to non-DR soybean at either the V3 or R1 stages of growth. The treatments evaluated included the diglycolamine (DGA) salt of dicamba with VaporGrip at rates corresponding to 1/10th, 1/100th, 1/1,000th, and 1/10,000th of the labeled use rate (560 g ae ha^{-1}) and lactofen at 175 g ae ha^{-1}. A non-treated control was also included for comparison. The experiment was conducted in a randomized complete block design with individual plots 6 by 6 m and replicated six times. Insects were collected by sweep net sampling beginning the day of application and at 7 day intervals up to R5 soybean. Upon collection, all insects were frozen and stored for subsequent identification and analysis. Data were subjected to analysis using the PROC GLIMMIX procedure in SAS and means were separated using Fisher's Protected LSD ($P \leq 0.05$). Results from all locations indicate that insect pest and beneficial species abundance was lowest in non-DR soybean that received an application of dicamba at 1/10th the labeled rate at either the V3 or R1 application timing. Incidence of pest species was lower than that of the non-treated control following application of lactofen and dicamba at 1/100th, 1/1,000th, and 1/10,000th of the labeled rate, but remained higher than what occurred following treatment with 1/10th the labeled rated of dicamba. However, beneficial insect species density was not different from the non-treated control following treatment with lactofen and dicamba at 1/100th, 1/1,000th, and 1/10,000th the labeled rate. Results indicate that dicamba injury to non-DR soybean does not result in higher incidence of insect pest or beneficial species compared to non-injured soybean.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

†Response of Non Dicamba-Tolerant Soybean Varieties and Traits to Dicamba. Tyler P. Meyeres*[1], Sarah Lancaster[1], Dallas E. Peterson[1], Vipan Kumar[2]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS (174)

ABSTRACT

Introduction and rapid adoption of dicamba-tolerant soybean (*Glycine max*) led to an increase of POST applications of dicamba for weed control during the soybean growing season, resulting in non-target dicamba injury to non-tolerant soybeans. This in-season dicamba use also raised the risk of dicamba injury to non dicamba-tolerant soybean from off-target movement and spray tank contamination. Moreover, the response of non dicamba-tolerant soybean varieties with various herbicide tolerant traits to dicamba drift is not well understood. To fill this research gap, field studies were conducted at Kansas State University in Manhattan, KS during 2018 and 2019 and in Ottawa, KS in 2019 to investigate the injury and yield response of soybean varieties with varying traits and maturities when exposed to dicamba. Four soybean varieties were tested: 'Credenz 3841LL' (Liberty Link)', 'Credenz 4748LL' (Liberty Link)', 'Asgrow 4135RR2Y' (RoundUp Ready)', and 'Stine 40BA02' (glyohosate and isoxafultole tolerant'). Soybean varieties were exposed to 2.47 g ae ha^{-1} (1/100X) of dicamba at V3 and R1 growth stages. All experiments were conducted in split-plot design with four replications. Main plots included soybean varieties and split plots included two soybean growth stages when dicamba was applied. Percent visible soybean injury was evaluated at four weeks after treatment (WAT) and at onset of senescence. Soybean injury symptoms, including leaf cupping, brittle leaves, and damage to terminal buds were observed in all soybeans treated during the V3 growth stage. In addition to aforementioned symptoms, stunting, pod curling, and the accumulation of callus tissue appeared in soybeans treated at the R1 growth stage. Four weeks after exposure at V3, the greatest injury was observed in 'Asgrow AAG4135RR2Y' and 'Stine 40BA02' across all locations. Exposure at the R1 growth stage resulted in 'Stine 40BA02' showing the greatest injury at both four WAT and onset of senescence across all locations. At the onset of senescence, minimal injury was observed in soybeans exposed at V3 and injury was observed to be 10% or less across all varieties at all locations. Non-treated check yields varied among varieties at each site-year. Exposure at V3 resulted in a 5% or less yield reduction across all varieties. Exposure at R1 caused 19, 20, 25, and 34% yield loss in 'Credenz 4748LL', 'Asgrow AG4135RR2Y', 'Credenz 3841LL', and 'Stine 40BA02', respectively. Exposure at R1 caused the greatest injury and yield loss across all varieties, while exposure at V3 resulted in minimal injury and yield reduction across all varieties. Varieties with greater injury at senescence generally yielded less than other varieties.

†Soybean Symptomology and Yield Response to Sub-Labeled Doses of Dicamba and 2,4-D. Jesaelen G. Moraes*[1], Vitor M. Anunciato[2], Jeffrey A. Golus[1], Kasey P. Schroeder[1], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]FCA/UNESP, Botucatu, Brazil (175)

ABSTRACT

Purported soybean injury due to unintended off-target movement of dicamba and 2,4-D has raised concerns. The objective of this study was to investigate the symptomatology and consequent impact on yield caused by exposition of plants to sub-labeled doses of two auxin herbicides (dicamba and 2,4-D) on the several commonly used soybean cultivars in Nebraska. The experiment was conducted at the West Central Research and Extension Center, in North Platte, NE, as a randomized complete block design with a split-plot design arrangement and four replications. Main plots consisted of eight soybean cultivars (Hoegemeyer 2511NRR, Hoegemeyer 2811NR, Asgrow 2636, Pioneer P27T59R, Pioneer P22T41R2, Syngenta S26-F4L, Syngenta S28-6L, Basf CZ2312LL), and sub-plot consisted of five doses of dicamba (0.0056, 0.056, 0.56, 5.6, and 56 g ae ha^{-1}), and five doses of 2,4-D (0.01065, 0.1065, 1.065, 10.65, 106.5 g ae ha^{-1}) applied as late POST (~R1). Herbicide applications (140 L ha^{-1}) were made using a commercial sprayer equipped with 15 independently spray booms using the TTT11003 nozzle at 276 kPa and a travel speed of 9.6 kph. A control plot (no herbicide) was included for a total of 88 treatments. Plots were kept weed free from planting to harvest. Visual estimation of injury was collected at 7, 14, 21, and 28 d after application (DAA). Plant heights were collected at 14, and 28 DAA. Number of pods per plant, number of seeds per pod, 100 seed weight, and total seed mass were recorded for six plants from each plot at harvest, as well as soybean grain yield. Data were subjected to analysis of variance and dose-response curves were fitted to the data using the log-logistic function of the dr4pl package in R 3.4.2. Overall, at 28 DAA no differences were observed in plant reduction when comparing herbicides at the same dose across soybean cultivars with the exception of the highest dose where a greater plant reduction was observed when using dicamba. The level of plant reduction varied according to the cultivar and herbicide being used. Drastically yield reduction was observed when plants were exposed to the highest dose of dicamba suggesting that soybean plants are more sensitive to dicamba than to 2,4-D. However, this trend is buffered as the dose is reduced. Slight increase in yield was observed when plants were exposed to the lowest doses of either dicamba or 2,4-D for at least half of the cultivars. The cultivars with the trait RR2Y (Asgrow 2636 and P22T41R2) showed to be the most sensitive when exposed to sub-labeled doses of dicamba and 2,4-D.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

†The Effects of Adjuvants and Carrier Water Characteristics on Dicamba Volatilization in a Controlled Environment. Nicholas C. Hayden*, Julie M. Young, Manoj S. Ghaste, William G. Johnson, Joshua R. Widhalm, Bryan G. Young; Purdue University, West Lafayette, IN (176)

ABSTRACT

Exposure of sensitive soybean to the off-target movement of dicamba from applications in dicamba-resistant soybean has been a major concern and topic of debate since 2017. Although restrictions continue to expand on how dicamba may be applied to dicamba-resistant soybean, stakeholders continue to seek a broader understanding of all the factors that drive off-target movement of dicamba, especially volatile drift. Controlled environment experiments were conducted to quantify the effects of 1) spray additives sold as drift reduction agents, 2) spray solution ions that may be found in water supplies used as spray carrier, 3) a range of spray solution pH, and 4) suspended soil in carrier water on the relative volatilization of three dicamba formulations from application to dicamba-resistant soybean. Dicamba diglycolamine (DGA), diglycolamine with VaporGrip® (DGA + VG), or N,N-Bis-(3-aminpropyl)methylamine (BAPMA) was applied to dicamba-resistant soybean at a rate of 560 g ae ha^{-1} and placed into a closed chamber for 48 h while sampling the air for dicamba vapor. Drift reduction agents resulted in no significant increase of dicamba volatilization compared with dicamba applied alone across all three formulations. Additionally, turbid carrier water from suspended high organic matter or high clay soil in the spray solution did not result in increased volatilization compared with dicamba alone. At a spray solution pH of 3.0, dicamba volatilization was increased 2.8X and 3.9X for the DGA + VG and BAPMA formulations, respectively, compared with each respective dicamba formulation applied alone with no pH adjustment (pH 5.4 to 6.4). However, spray solution pH levels of 4, 5, and 6 were not different from dicamba alone for the BAPMA and DGA + VG formulations. The presence of diammonium sulfate and ferrous sulfate in the carrier water resulted in volatilization increases of at least 5X and 9X, respectively, compared with each dicamba formulation applied alone. In conclusion, this research suggests that drift reduction agents and turbid carrier water are not major factors that would contribute to dicamba volatility. Furthermore, spray pH levels from 4 through 6 don't demonstrate any greater potential for dicamba volatility when applied to soybean leaf surfaces. When considering equal concentrations of cations found in water supplies, the presence of iron and ammonium can increase dicamba volatility independent of any change in spray pH. A critical aspect of this research is the influence of these factors when applied to soybean leaf surfaces, which may differ when applied to soil or glass surfaces.

†Dicamba Simulated Tank-Contamination in Common Postemergence Non-Dicamba-Tolerant Soybean Herbicide Programs. Milos Zaric*, Guilherme S. Alves, Bruno C. Vieira, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (177)

ABSTRACT

Development of dicamba-tolerant (DT) crops was driven by a need for broad-spectrum and viable herbicide options for postemergence weed control in soybean. Even though DT crops have provided farmers a feasible approach to control troublesome weeds, there are some concerns associated with dicamba off-target movement and its effects on sensitive broadleaf vegetation. Currently, there are few available studies that evaluate dicamba presence as a tank contaminant. There are even less studies that report the impact of dicamba on sensitive crops when found with different tank-mixtures. Field experiments were conducted in 2018 and 2019 to evaluate the impact of commonly applied postemergence herbicides with simulated dicamba tank contamination on non-DT soybean (*Glycine max* (L.) Merr.) The experiment was conducted in a randomized complete block design with a factorial arrangement with four replications. Each plot consisted of six rows of non-DT soybean (0.76 m apart and 10 m long). Treatments included untreated check, two glyphosate formulations, and three PPO-inhibiting herbicides combined with one of three sub-labeled rates of dicamba as tank contaminants (0, 0.1, and 0.01% of the 560 g ae ha^{-1} rate). Herbicide treatments were applied on two soybean fields at different growth stages (V_3 and R_1, respectively) using a CO_2 backpack sprayer with a six-nozzle boom calibrated to deliver 140 L ha^{-1} using AIXR110015 nozzles at 345 kPa. Visual estimation of injury and plant height were recorded at 28 days after treatment (DAT). Soybean yield was also collected by harvesting the two middle rows of each plot. Results showed that soybean symptomatology and impact on the plant height depended on interaction between herbicide and sub-labeled rates of dicamba, regardless of soybean stage and growing season. Differently than results from 2018, yield was not affected by herbicide and dicamba rates when sprayed at V_3 and R_1 growth stages in 2019, being on average 5445 and 5233 ka ha^{-1}, respectively. In 2018, lactofen reduced in 9% the yield of soybean exposed at R_1 compared with one formulation of glyphosate regardless of dicamba rate; however, soybean exposed to both products produced similar yield compared with untreated plants (5335 kg ha^{-1}). Soybean injury caused by dicamba rates up to 0.56 g ae ha^{-1} as tank contaminant in applications of glyphosate and PPO-inhibiting herbicides did not lead to yield reduction of soybean exposed at V_3 and R_1 growth stages in 2018 and 2019 growing seasons. Even tough, that applied herbicides caused more visible symptoms and impacted plant height final impact on soybean yield need to be considered as complexed biological process that is commonly dose dependent and may not always result in yield loss.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

Management of Volunteer Corn with Fusilade DX Plus Dicamba Tank Mixes. Marshall M. Hay*[1], Ethan T. Parker[1], Peter M. Eure[2]; [1]Syngenta Crop Protection, Vero Beach, FL, [2]Syngenta Crop Protection, Greensboro, NC (178)

ABSTRACT

Volunteer corn can significantly reduce soybean yield if left uncontrolled. Soybean yield loss caused by volunteer corn is dependent on the density and duration of interference. Management of volunteer corn in soybean includes reducing corn grain losses at harvest, tillage, cultivation, and chemical control. Use of Group 1 herbicides in soybeans to control glyphosate tolerant volunteer corn is common.

Commercialization of dicamba tolerant soybean (*Glycine max* L. (Merr.)) increased the frequency of dicamba and Group 1 herbicide tank mixtures for control of glyphosate tolerant volunteer corn (*Zea mays* L.). Previous research documented the antagonism of monocot control when dicamba is added to Group 1 herbicides. Therefore, the objectives of this research were to (1) Evaluate Fusilade® DX (fluazifop-P-butyl) herbicide volunteer corn control with and without dicamba (2) Discuss factors that influence volunteer corn control when using Fusilade DX + dicamba tank mixtures.

This research concluded that Fusilade DX is an effective tool for managing volunteer corn in soybeans when tank mixed with and without dicamba. Volunteer corn management may also be influenced by corn height, tank mix partners, and adjuvants.

Pre-Emergence Followed by Post-Emergence Residual Herbicide Programs with XtendiMax® Herbicide with VaporGrip® Technology in Roundup Ready 2 Xtend® Soybeans. Neha Rana*[1], Rod Stevenson[2], Ryan Rapp[3], Blake Barlow[4]; [1]Bayer CropScience, St Louis, MO, [2]Bayer CropScience, Lansing, MI, [3]Bayer CropScience, Mitchell, SD, [4]Bayer CropScience, Columbia, MO (179)

ABSTRACT

XtendiMax® herbicide with VaporGrip® Technology provides an effective site of action (SOA) to control glyphosate and PPO-resistant weed species. It is recommended to use XtendiMax herbicide with VaporGrip technology with residual herbicides in pre-emergence and post emergence applications that have different, effective sites of action, along with other diversified weed management practices. In 2019, 18 field studies were conducted in IA, IN, IL, MI, MN, MO, MD, NE, and WI. Eight of these trials were conducted with university academics. The objective of the field studies was to examine weed control when XtendiMax herbicide is applied in preemergence application with a traditional residual herbicide followed by post-emergence application (20-30 days after soybean planting) with XtendiMax (0.5 lb ae A^{-1}) + Warrant® herbicide (1.125 lb ai A^{-1}) + Roundup PowerMAX® herbicide (1.125 lb ae A^{-1}) + approved drift reduction adjuvant. Results indicated greater than 96% and 93% weed control at 28 and 42 days after treatment, respectively, when overlapping residual herbicide programs were used with XtendiMax herbicide with VaporGrip technology.

XtendiMax® with VaporGrip® Technology is a Restricted Use Pesticide.

Papers: Agronomic and Specialty Crops

Response of Popcorn and Sweet Corn Hybrids to Acuron and Acuron Flexi Applied Preemergence and Postemergence. Debalin Sarangi*[1], Martin Williams[2], Amit J. Jhala[3]; [1]University of Wyoming, Laramie, WY, [2]USDA, Urbana, IL, [3]University of Nebraska-Lincoln, Lincoln, NE (180)

ABSTRACT

NO ABSTRACT SUBMITTED

†Assessment of HPPD-Inhibitor Damage Using Unmanned Aerial Vehicles and High-Resolution Multispectral Imagery in Grain Sorghum (*Sorghum bicolor*). Isaac H. Barnhart*, Sushila Chaudhari, Balaji A. Pandian, Ignacio A. Ciampitti, Mithila Jugulam; Kansas State University, Manhattan, KS (181)

ABSTRACT

Manual evaluation of crop injury in response to herbicide application in field trials can be time-consuming and labor-intensive. Use of small unmanned aircraft systems (sUAS) equipped with high-resolution multispectral sensors have the potential to save time and obtain reliable evaluation of herbicide injury in crops, including grain sorghum. Our previous research has identified sorghum genotypes with elevated tolerance to HPPD-inhibitors (e.g. mesotrione and tembotrione), although cultivated varieties can be sensitive to these herbicides. The objective of this research was to assess the herbicide injury of HPPD-inhibitor-tolerant and -susceptible sorghum genotypes using sUAS. Two field experiments were conducted in a randomized complete block design using a factorial treatment arrangement of three genotypes by four herbicide (mesotrione or tembotrione) rates. Herbicide injury was rated visually on a scale of 100 (no damage) to 0 (complete plant death). Flights were flown at 9, 15, 21, 27, and 35 days after treatment. To evaluate differences in plant height upon herbicide treatments, a digital surface model (DSM) was constructed; correlation and regression analyses were employed to evaluate relationships between vegetative indices (VIs) and ground-measured data. Results indicate a significant linear relationship (R^2 = 0.84-0.94) between DSM and ground-measured height measurements across all treatments. Additionally, significant correlations were found between visual injury ratings and computed VIs, while the highest correlation coefficient was found for the Simple Ratio (SR). We can therefore conclude that the data collected from sUAS platforms has potential to be an effective method of evaluating the HPPD-inhibitor injury in grain sorghum.

GF-4030, A New Broadleaf Herbicide for Cereals from Corteva Agriscience. Dave Johnson*[1], Joe Yenish[2], Patti Prasifka[3], Michael Moechnig[4]; [1]Corteva Agriscience, Eagan, MN, [2]Corteva Agriscience, Billings, MT, [3]Corteva Agriscience, West Fargo, ND, [4]Corteva, Toronto, SD (182)

ABSTRACT

NO ABSTRACT SUBMITTED

Control of Emerging Weed Threats in the Northern Plains with Pixxaro EC Herbicide. Jeffrey Krumm*[1], Bruce Steward[2], Joseph Yenish[3], David Johnson[4], Patricia Prasifka[5], Michael Moechnig[6]; [1]Corteva, Hastings, NE, [2]Corteva, Oklahoma City, OK, [3]Corteva, Billings, MT, [4]Corteva, Eagan, MN, [5]Corteva, Fargo, ND, [6]Corteva, Toronto, SD (183)

ABSTRACT

NO ABSTRACT SUBMITTED

†Glyphosate-Resistant Canada Fleabane (*Conyza canadensis*) and Giant Ragweed (*Ambrosia trifida*) Control in Winter Wheat with Halauxifen-Methyl Applied POST. Jessica Quinn*[1], Jamshid Ashigh[2], Dave Hooker[1], Darren Robinson[1], Peter Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]Corteva Agriscience, London, ON (184)

ABSTRACT

Canada fleabane is a competitive summer or winter annual weed that produces up to 230,000 small seeds per plant that are capable of travelling more than 500 km via wind. Giant ragweed is a tall, highly competitive summer annual weed. Populations of glyphosate-resistant (GR) Canada fleabane and GR giant ragweed can be found in the United States and southwestern Ontario, Canada, posing significant challenges for wheat producers. Halauxifen-methyl is a new, selective, broadleaf, postemergence herbicide for use in cereal crops; there is limited information on its efficacy on GR Canada fleabane and GR giant ragweed. Two studies, each consisting of 6 field experiments, completed over a two-year period (2018, 2019) were conducted to determine the efficacy of halauxifen-methyl applied postemergence (POST), alone and in a tank-mix, for the control of GR Canada fleabane and GR giant ragweed in wheat across southwestern Ontario at sites with confirmed GR Canada fleabane and GR giant ragweed populations. At 8 weeks after application (WAA), halauxifen-methyl, fluroxypyr/halauxifen, fluroxypyr/halauxifen + MCPA EHE, fluroxypyr + MCPA ester, 2,4-D ester, clopyralid, and pyrasulfotole/bromoxynil + AMS controlled GR Canada fleabane 95, 97, 97, 95, 97, 97 and 98%, respectively. Fluroxypyr and MCPA provided only 86 and 37% control GR Canada fleabane, respectively. At 8 WAA, fluroxypyr, fluroxypyr/halauxifen, fluroxypyr/halauxifen + MCPA EHE, fluroxypyr + MCPA ester, fluroxypyr/halauxifen + MCPA EHE + pyroxsulam, 2,4-D ester, clopyralid, and thifensulfuron/tribenuron + fluroxypyr + MCPA ester controlled GR giant ragweed 87, 88, 90, 94, 96, 96, 98 and 93%, respectively. Halauxifen-methyl and pyroxsulam provided only 45and 28% control of GR giant ragweed, respectively. This study concludes that halauxifen-methyl, applied POST in the spring controls GR Canada fleabane but not GR giant ragweed in winter wheat.

Sugarbeet Tolerance and Weed Control from Postemergence Ethofumesate 4SC. Alexa L. Lystad*, Thomas J. Peters; North Dakota State University, Fargo, ND (185)

ABSTRACT

Sugarbeet (*Beta vulgaris* L.) is a high value, root crop with approximately 18% sucrose content in the root. Weed control is an important component in profitability of sugarbeet production. Weeds can also affect sugarbeet quality by reducing sucrose percentage and decreasing the aesthetics of production fields. Ethofumesate is a broad spectrum, soil-applied herbicide for control of broadleaf and grass weeds in sugarbeet. Some weed species controlled with ethofumesate are common lambsquarters (*Chenopodium album* L.), redroot pigweed (*Amaranthus retroflexus* L.), barnyardgrass (*Echinochloa crus-galli*), and wild oat (*Avena fatua* L.), which are known to reduce yield in sugarbeet. Ethofumesate is a commonly used soil-applied herbicide at rates ranging from 1.25 to 4.2 kg ha^{-1} or can be used postemergence at 0.38 kg ha^{-1}. Generic Crop Science has developed a new Ethofumesate 4SC label that increases postemergence use rates from 0.38 to 4.48 kg ha^{-1} to sugarbeet with greater than two true leaves. In 2017, a probe study was conducted to evaluate Ethofumesate 4SC mixtures with glyphosate. Repeat applications of ethofumesate at 0.21, 0.42, 0.63, 0.84, 1.12, and 2.24 kg ha^{-1} were applied to two leaf and six leaf sugarbeet. Researchers reported ethofumesate across rates provided up to 78% and 75% common lambsquarters and redroot pigweed visual control, respectively. The researchers also reported up to 100% waterhemp (*Amaranthus tuberculatus* (Moq.) J.D. Sauer) visual control, presumably since waterhemp germinates and emerges later and throughout the season as compared to common lambsquarters or redroot pigweed. Field and greenhouse experiments were conducted in 2018 and 2019 to further evaluate sugarbeet tolerance and herbicide efficacy. Field tolerance experiments conducted across multiple environments indicated stature reduction from ethofumesate POST at 0.28 0.56, and 1.12 kg ha^{-1} was the same as the untreated control. Ethofumesate at 2.24 kg ha^{-1} reduced stature but did not affect root yield, percent sucrose or recoverable sucrose as compared to the untreated control. Ethofumesate at 4.48 kg^{-1} reduced stature and affected sugarbeet yield. Ethofumesate alone provided up to 85%, 76%, and 84% common lambsquarters, redroot pigweed, and waterhemp control, respectively 14 DAT in field experiments across multiple environments in 2018 and 2019. Mixing ethofumesate at 1.12 kg $ha^{-1}$with glyphosate does not provide a second effective herbicide for common lambsquarters and redroot pigweed control but improves overall control, especially 14 DAT. Mixing ethofumesate at 2.24 kg ha^{-1} with glyphosate improved waterhemp control from 53% to 91% control. In greenhouse experiments, ethofumesate alone or ethofumesate plus glyphosate timed to common lambsquarters, redroot pigweed, or waterhemp less than 1.3-cm provided the best combination of burndown and soil residual control compared to the same weeds 2.5- to 5-cm tall weeds. Ethofumesate 4SC has very little postemergence activity on emerged weed species, however, provides residual benefits to postemergence glyphosate applications when activing rainfall is present. Ethofumesate 4SC at 1.12 kg ha^{-1} plus glyphosate provided the greatest weed control across species with the least sugarbeet stature reduction.

†Sugarbeet Tolerance and Weed Efficacy with Acifluorfen. Emma L. Larson*[1], Thomas J. Peters[2]; [1]North Dakota State University, Wahpeton, ND, [2]North Dakota State University, Fargo, ND (186)

ABSTRACT

Waterhemp (*Amaranthus tuberculatus* [Moq.] J.D. Sauer) is the most important weed control challenge in sugarbeet production in Minnesota and North Dakota. Glyphosate, ethofumesate, and triflusulfuron are currently the only options for postemergence broadleaf weed control in sugarbeet. However, biotypes resistant to glyphosate (SOA 9) and ALS inhibitors (SOA 2) have marginalized their efficacy against waterhemp and have created a need to develop novel postemergence herbicide solutions. Previous research indicated crop tolerance of sugarbeet to acifluorfen, a postemergence herbicide providing effective waterhemp control and control of other broadleaf weeds including kochia (*Bassia scoparia* [L.] A. J. Scott), redroot pigweed (*Amaranthus retroflexus* L.), Palmer amaranth (*Amaranthus palmeri* S. Watson), and Pennsylvania smartweed (*Persicaria pensylvanica* [L.] M. Gomez). Acifluorfen applied in a weed management system with soil residual herbicides and glyphosate would control broadleaf escapes in sugarbeet. Field experiments conducted across multiple environments evaluated sugarbeet tolerance to acifluorfen to determine if visible injury translated to loss of root yield, % sucrose, or recoverable sugar in 2019. Acifluorfen at 0.28 kg ha^{-1} plus non-ionic surfactant (NIS) at 0.25% v v^{-1} was applied to 2-, 4-, and 10-lf sugarbeet. Stature reduction observed up to 10 days after treatment (DAT) on 2- and 4-lf sugarbeet was not observed on 10-lf sugarbeet although visible necrosis was observed following acifluorfen application across sugarbeet growth stages. Stature reduction after 10 DAT generally was negligible except from acifluorfen at 0.43 kg ha^{-1} plus NIS at the 4-lf stage. Root yield, % sucrose, and recoverable sucrose measurements were not affected by acifluorfen although root yield and recoverable sucrose tended to increase when acifluorfen application was delayed to 10-lf sugarbeet compared to application at the 2- or 4-lf sugarbeet. Field weed efficacy experiments conducted across multiple environments confirmed acifluorfen as an effective postemergence waterhemp control option in sugarbeet. Acifluorfen at 0.15, 0.28, and 0.43 kg ha^{-1} plus NIS provided 46%, 60%, and 68% visual waterhemp control, respectively, 10 or more DAT. Crop oil concentrate, methylated seed oil, or high surfactant methylated oil concentrate with acifluorfen improved waterhemp control compared to NIS with acifluorfen although oil-based adjuvants with acifluorfen also increased sugarbeet injury compared to NIS with acifluorfen. Tank mixtures with acifluorfen improved waterhemp control compared to acifluorfen alone. Acifluorfen and glyphosate at 0.28 and 1.10 kg ha^{-1} with NIS gave 87% waterhemp control compared to 60% control from acifluorfen alone and 37% control from glyphosate alone, 10 or more DAT. These results indicate acifluorfen could be a valuable sugarbeet herbicide for postemergence broadleaf weed control, especially waterhemp.

Three Chipping Potato Cultivar Responses to Simulated Dicamba and Glyphosate Drift. Matthew Brooke, Harlene M. Hatterman-Valenti*, Collin W. Auwarter; North Dakota State University, Fargo, ND (187)

ABSTRACT

The effects of sublethal drift rates of glyphosate and dicamba on seed potato cultivars Atlantic and Dakota Pearl are unknown. This research explores the effects of glyphosate and dicamba measured through visible injury, as well as tuber yield, and quality reduction. Herbicides were applied at the potato tuber initiation stage and consisted of dicamba rates of 0, 20, and 99 g ae ha^{-1} and glyphosate rates of 0, 40, and 197 g ae ha^{-1}. At 7 days after treatment (DAT), the spray combination of glyphosate (197 g ae ha^{-1}) and dicamba (99 g ae ha^{-1}) resulted in the most plant damage, at 28% based on visible ratings from 0% (no injury) to 100% (plant death). Plant injury from glyphosate (40 g ae ha^{-1}) and dicamba (20 g ae ha^{-1}) was similar to the non-treated. At 21 DAT, visible injury increased to 40% for the combination of glyphosate (197 g ae ha^{-1}) and dicamba (99 g ae ha^{-1}) treatment. Tuber specific gravity was lower for plants sprayed with any herbicide treatment that included dicamba. Results from the two field trials suggest that sublethal combinations of glyphosate (197 g ae ha^{-1}) and dicamba (99 g ae ha^{-1}) decreased potato yields and tuber specific gravity.

Pyroxasulfone Use on Dryland and Irrigated Faba Beans. Harlene M. Hatterman-Valenti*, Burton Johnson, Collin W. Auwarter, Kutay Yilmaz; North Dakota State University, Fargo, ND (188)

ABSTRACT

Grain legumes are important components of cereal-dominated cropping systems in North Dakota due to their ability to fix atmospheric nitrogen, break graminaceous crop disease cycles, and improve soil quality. Unfortunately, the weed control options are rather limited. In 2019, four trials (two irrigated, two dryland) were conducted to evaluate pyroxasulfone preemergence use for weed control and crop safety using faba bean. In general, control of common lambsquarters, common purselane, redroot pigweed, and annual grasses (primarily green foxtail) increased with increasing rate of pyroxasulfone for the dryland locations. Control of common purselane, redroot pigweed, and annual grasses (primarily green foxtail) was excellent with all pyroxasulfone rates for the irrigated locations. Common lambsquarters control at the irrigated site near Absaraka, ND increased with increasing pyroxasulfone rates. Crop injury was slightly greater with irrigation, but was less than 10% for all treatments. Faba beans were harvested but yield data has not been analyzed. Overall results suggest that pyroxasulfone could provide growers another weed management tool when producing faba bean.

Seeding and Nitrogen Rate Influence Canopy Closure and Weed Suppression in Industrial Hemp (*Cannabis sativa*). Haleigh J. Ortmeier-Clarke*[1], Nicholas J. Arneson[1], Maxwel C. Oliveira[1], Jerome Clark[2], Carrie Laboski[1], Shawn Conley[1], Rodrigo Werle[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin-Madison, Chippewa Falls, WI (189)

ABSTRACT

Wisconsin emerged as a leading producer of industrial hemp (*Cannabis sativa*) as a fiber crop in the early 1900s. Under the Controlled Substances Act, cannabis was listed as a Schedule I drug, making it illegal to produce. However, the 2018 Farm Bill identified industrial hemp as *Cannabis sativa* L. with < 0.3% tetrahydrocannabinols (THC), separating it from *Cannabis sativa* L. with > 0.3 % THC (otherwise known as marijuana). Farmers can again legally cultivate this crop, which has led to many questions regarding best management practices, especially surrounding cultivar selection as well as weed and nutrient management. The objective of this study was to compare industrial hemp grain cultivars and evaluate canopy closure, weed suppression, and grain and fiber yield in response to variable seeding and nitrogen rates. The study was conducted as a factorial with 2 cultivars (X-59 and CRS-1) x 3 Seeding Rates (22, 34, and 45 kg ha^{-1}) x 3 Nitrogen Rates (0, 67, and 134 kg ha^{-1}) in a RCBD (4 replications) at two locations, Southern Wisconsin (Arlington Agricultural Research Station) and in Northwest Wisconsin (Chippewa County Farm). The data from this study is still being analyzed and will be presented at the North Central Weed Science Society Annual Meeting in December 2019. Preliminary analyses indicate that seeding rate, and nitrogen response influence growth and yield of industrial hemp and also the crop's ability to suppress weeds. The study will be replicated in 2020. These results will allow us to provide baseline recommendations to growers producing industrial hemp for grain and fiber in the state of Wisconsin and surrounding states.

Aminopyralid + 2,4-D (NativeKlean): A New Herbicide for Native Grass Roughs on Golf Courses. David Hillger*[1], Amy Agi[2], Brad Hopkins[3]; [1]Corteva AgriScience, Thorntown, IN, [2]Corteva AgriScience, Brooks, GA, [3]Corteva AgriScience, College Station, TX (190)

ABSTRACT

Naturalized areas are an increasingly common trend on golf courses. These areas of tall grass and native vegetation not only reduce inputs, but they enhance wildlife habitat; however, these areas still require maintenance. To simplify native and naturalized area management, NativeKlean™ herbicide, the premix of aminopyralid and 2,4-D amine, was specifically designed to be a low-maintenance solution. With application flexibility and long residual control, NativeKlean enables efficient use of limited resources while controlling high-anxiety herbaceous weeds, including Canada thistle (*Cirsium arvense*), cocklebur (*Xanthium strumarium*), horsenettle (*Solanum carolinense*), pigweed (*Amaranthus* spp.), plantain (*Plantago* spp.) and ragweed (*Ambrosia spp*.).

Arylex, 2,4-D Choline + Fluroxypyr (GameOn): A New Herbicide for Broad-Spectrum Weed Control in Turf. David Hillger*[1], Amy Agi[2], Brad Hopkins[3]; [1]Corteva AgriScience, Thorntown, IN, [2]Corteva AgriScience, Brooks, GA, [3]Corteva AgriScience, College Station, TX (191)

ABSTRACT

GameOn™ specialty herbicide is a broad-spectrum postemergence herbicide with the new active ingredient Arylex™ (halauxifen-methyl), 2,4-D choline, and fluroxypyr. GameOn™ is a fast-acting, systemic herbicide effective on more than 100 broadleaf weeds such as ground ivy (*Glechoma hederacea*), henbit (*Lamium amplexicaule*), plantain (*Plantago* spp.), oxalis (*Oxalis* spp.), clover (*Trifolium* spp.), dandelion (*Taraxacum officinale*), chickweed (*Stellaria media*) and doveweed (*Murdannia nudiflora*). GameOn is recommended for use on cool-season turfgrass like bentgrass (*Agrostis stolonifera*), bluegrass (*Poa prantensis*), tall fescue (*Festuca arundinacea*), fine fescue (*Festuca* spp.) and ryegrass (*Lolium perenne*) as well as warm-season turfgrasses like bermudagrass (*Cynodon dactylon*) and zoysiagrass (*Zoysia* spp.).

Papers: Weed Biology, Ecology, Management

†Evaluating the Effect of Mowing Timing and Frequency, Planting Timing and Cover Crop Use on the Establishment of Planted Pollinator Species (forbs). Mark Renz, Jasmine Wyant*, Niels Jorgensen; University of Wisconsin-Madison, Madison, WI (192)

ABSTRACT

Conservation plantings to promote pollinator species (forb species that are a nectar source for pollinating animals) are of growing interest in Wisconsin and beyond. Weed management in these plantings varies greatly and while management recommendations exist, they lack details on the proper timing or frequency of management and are rarely quantitatively evaluated. The objective of this study was to test common and novel weed management methods for pollinator establishment. Management practices evaluated include mowing timing (when bare ground <10% versus 1 month later), mowing frequency (1x versus 2x), the use of a companion crop (oats), PRE herbicides at planting (imazapic+glyphosate), and PRE herbicides in spring one year after establishment (flumioxazin+glyphosate, pendimethalin+glyphosate). These parameters were evaluated in two experiments planted at different timings at two Wisconsin locations (Janesville and Lancaster, WI). Both experimental locations were planted with NRCS standard CP25 pollinator mix in 2018 in late April or early June. Treatments were applied at planting (companion crop), immediately after planting (imazapic + glyphosate), the summer of the establishment year (mow on time, mow late, mow 2x) or the first week of May one year after planting (flumioxazin+glyphosate, pendimethalin+glyphosate). The experimental design was a randomized complete block design with companion crop and weed management method as factors. Individual planted forb density was estimated in the summer of 2019 and the cover of plant functional groups was visually estimated in the fall of 2019. Results were analyzed with SAS proc mixed with companion crop and management method as fixed effects and block and site as random. If differences existed mean separations occurred with LS-means at a $p<0.05$. Including a companion crop did not impact the total planted forb density (0.3 and 0.4 plants m^{-2} in early and late planting respectively) or richness (0.07 and 0.08 plants m^{-2} in early and late planting respectively) 1 YAP. Of the ten planted forbs only black-eyed Susan (*Rudbeckia hirta*) had reduced density due to the companion crop (30%), but only in the early planting. Similarly, mowing treatments did not impact pollinator density (0.2 and 0.3 plants m^{-2} in early and late planting respectively) and richness (0.08 and 0.09 plants m^{-2} in early and late planting respectively) 1 YAP. The application of imazamox at planting also did not impact total pollinator density or richness 1 YAP, but reductions in densities of prairie coneflower (*Ratibida pinnata*) and wild bergamot (*Monarda fistulosa*) were observed with some planting timings and rates. Herbicides applied for residual control of annual weeds in the spring of the second year (flumioxazin+glyphosate, pendimethalin+glyphosate) reduced pollinator richness (35-65%) and total density (29-62%) compared to the control plots. Eighteen months after planting no differences in total forb cover was observed within the early or late planting (10% for each planting time).

Results suggest pollinator species did not benefit from the weed management methods employed 12-18 months after planting. While results may discourage weed management, cropping history and weed community composition (> 90% annual weeds) may be a driving factor in the observed results.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

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†Function of Cover Cropping and Herbicide Use When Managing Marestail. Ryan J. Collins*; University of Kentucky, Lexington, KY (193)

ABSTRACT

Application of sustainable weed management practices is one of the largest challenges farmers face going forward. Marestail (*Erigeron canadensis*) is a troublesome weed in row crops; herbicide resistance and shifting emergence patterns complicate its management. This collaborative project with four universities, (Kansas State, Kentucky, Missouri and Southern Illinois) seeks to provide a regional perspective on marestail biology and management. Objective 1 of this experiment is to characterize marestail emergence time and survival. Marestail is easier controlled shortly after emergence, so information on emergence timing will better inform management practices. Objective 2 is to determine how well cover crops (CC), herbicides, and combinations of the two suppress marestail emergence and growth in soybean. To quantify emergence timing, seeds from eight locations (two per state) were spread into PVC rings in the fall. Emerged seedlings were counted and removed regularly from late summer until early summer the following year, when conditions for marestail emergence were adequate.

The impact of management practices on marestail was examined in a no-till soybean field. Treatments contained different combinations of CC, fall applied and spring applied herbicides with different levels of residual activity. All treatments were compared to an untreated and weed-free control. Two permanent quadrants were established in each field plot where marestail seedlings were counted and removed. Tracking marestail density, across a variety of management strategies, throughout the year will allow comparisons to be made between these management practices. These counts began after the establishment of CC and were continued until the soybean harvest the next year. Cumulative marestail emergence in the field experiment was summed before (CC planting-CC termination) and after soybean planting.

Preliminary results from seedling emergence in the PVC rings show, in both IL and KY, over 90% of marestail emergence occurred in the fall, regardless of where the seeds originated. Given these outcomes, environmental conditions were adequate for marestail germination in the fall and suggests a CC or properly timed herbicide application would be needed to prevent winter survival.

In the field experiment, the majority of emergence occurred in October and early November. Prior to planting soybean in year two only, there was a significant state by treatment interaction. In year two, IL saw significantly lower cumulative marestail emergence prior to soybean planting in plots with a CC compared to those without a CC or herbicide application, which supports our hypothesis for Objective 2. No differences were found when comparing CC and CC plus spring herbicide treatments. Applying a fall herbicide without residual activity may not align with marestail emergence time, and was not as effective as a CC in this study. Planting a fall CC will combat fall emerging marestail without using a chemical herbicide. In both years cumulative emergence after soybean planting was lower in plots with spring applied herbicides compared to plots without spring herbicides. While environmental conditions seem to influence marestail emergence, and conditions can change each year, our findings suggest that planting a fall CC can contribute to marestail management.

Effect of Cover Crop Termination Timing on Weed Suppression. Kaity J. Wilmes*, Christopher Proctor; University of Nebraska-Lincoln, Lincoln, NE (194)

ABSTRACT

Cover crop biomass production has been associated with a variety of in-field benefits including weed suppression and soil erosion control. Determining the optimal time to terminate a cover crop that not only maximizes cover crop biomass and weed suppression, but also minimizes any detrimental effects on the subsequent cash crop can be challenging. The objectives of this study were to 1) determine spring cover crop biomass accumulation at 4 different termination timings, 2) evaluate the effect of biomass accumulation on weed suppression, and 3) evaluate the yield of the subsequent corn crop. Studies were conducted at three locations in eastern Nebraska under dryland conditions during the 2018-2019 growing season. In this study, cereal rye (*Secale cereale* cv. Elbon), triticale (*Triticosecale* Wittm. Ex A. Camus cv Fringe), and winter wheat (*Triticum aestivum* cv. Settler Cl) species were fall planted and spring terminated at -20, -10, 0, and +5 days relative to corn (*Zea mays*) planting date. Cover crop biomass, weed biomass, and weed density counts were collected prior to each cover crop termination timing. The subsequent corn crop was harvested in the fall of 2019. Results showed that as termination timing was delayed later into the spring, cover crop biomass increased. Delaying the termination date from 20 days before planting to 10 days before planting did not result in any gained biomass. Terminating the cover crops at plant or 5 days after corn planting date resulted in the greatest amount of accumulated biomass.

Impact of Cover Crop Termination Timing on Weed Suppression and Soybean Yields. Luke I. Chism*[1], J. Anita Dille[1], Gretchen Sassenrath[2], Kraig Roozeboom[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Parsons, KS (195)

ABSTRACT

The use of cover crops for weed management has become widely adopted in more recent years due to the continual evolution of herbicide-resistant weeds and the need for integrated weed management strategies. Cover crop management, specifically the time of termination, is a common concern for many growers. In Kansas, concerns arise when the cover crop acquires too much biomass, using a significant amount of soil moisture that is important for the following cash crop. The goal of this study was to determine the effect of cover crop termination timing on weed densities and on soybean yield. Experiments were conducted during the growing seasons of 2018 and 2019. In 2018 four experiments were performed on farmer fields and on one university experiment station. A winter cereal cover crop was drilled in the fall of 2017 and was then terminated with glyphosate using a standard four-nozzle backpack sprayer at three different times relative to the soybean planting date. These timings included, terminating 12-15 days before soybean planting, the day of planting and terminating seven days after planting. In 2019 three experiments were performed on farmer fields, and on one university experiment station, using cereal cover crop drilled in the fall of 2018 with the exception of one field that was drilled in the spring. The treatments in 2019 were the same as the previous year with an additional termination timing at 35 days before planting that represented "no cover". All experiments were designed as a randomized complete block with four replications. Weed counts were taken directly before termination and at 25 days after soybean planting. A post-emergence herbicide was applied to the experiments after the last weed count evaluation to ensure that competition from weeds was not a factor in soybean yield. Soybean was hand harvested from four m of the center two rows of each plot and then processed and weighed. Data analyses were run with a Kruskal-Wallace one-way analysis of variance using R. Results showed that there were no differences between cover crop termination timings and soybean yields for any sites across both years. In both 2018 and 2019 there were significant differences in weed density at 25 days after soybean planting in each of the cover crop termination timings. Weed suppression increased with delay in termination timing, with the greatest weed suppression from cover crop termination seven days after planting. This result is likely due to increased biomass accumulation by the cover crop. Therefore, we conclude that later termination timings can reduce the density of weeds without influencing soybean yield.

†Impact of Cover Crop, Irrigation, and Tillage on Kochia Emergence Patterns Across the US Great Plains. Ramawatar Yadav*[1], Prashant Jha[1], Andrew Kniss[2], Nevin C. Lawrence[3], Gustavo Sbatella[4]; [1]Iowa State University, Ames, IA, [2]University of Wyoming, Laramie, WY, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Wyoming, Powell, WY (196)

ABSTRACT

Kochia [*Bassia scoparia* (L.) A. J. Scott] is one of the most problematic weeds across the U.S. Great Plains. Due to the development of multiple herbicide-resistant kochia populations, which include resistance to EPSPS inhibitor, PS II inhibitors, ALS inhibitors, and synthetic auxins, there is very limited herbicide options to control this weed in cropping systems of this region. The problem is even more serious in sugar beet-based crop rotations due to the widespread occurrence of glyphosate and ALS-resistant kochia. These two herbicide chemistries are the only viable options for kochia control in sugar beet. Therefore, there is an immediate need to implement ecologically based weed management strategies to control this weed. Field experiments were conducted in 2017-2018 and repeated in 2018-2019 at four sites in MT, WY, and NE (north-south transect) to quantify the effect of cover crop, irrigation, and tillage on emergence patterns of kochia, with an ultimate goal to exhaust the kochia seed bank. A total of 44 kochia accessions were collected in 2016 from northern (Huntley, MT; Powell, WY) and southern (Lingle, WY; Scottsbluff, NE) regions, 11 accessions from each of the four locations. These 11 accessions were grown in bulk on edges of the experimental field at each location for seed production in 2017. Fully-mature seeds were cleaned and a known quantity of seeds were uniformly broadcasted in each plot in the fall of 2017. A strip-split-split plot design was used. Strip-plot factor included winter wheat cover crop vs. no cover crop. Split-plot factor included five irrigation treatments ranging from no irrigation to four irrigations, with timings depending on each irrigation district. Split-split-plot factor consisted of no tillage, tillage (to a depth of 10 cm) before irrigation, and tillage after irrigation. Emerged kochia seedlings were counted and removed from two permanent 1 m^2 quadrats placed at the center of each plot at a biweekly interval. Data were analyzed using a generalized linear mixed effects model to with cover crop, irrigation, and tillage as fixed effects. Data from one northern (MT) and one southern (NE) location are presented. Winter wheat used as a cover crop did not influence kochia emergence patterns. Irrigation and tillage treatments did not influence kochia emergence at the MT site. In contrast, irrigation and tillage treatments significantly improved kochia emergence from the seed bank at the NE site. Kochia emergence increased with an increase in the number of irrigations; plots that received three irrigations had 80% compared to 60% emergence in plots that received no irrigation. Similarly, tillage after irrigation had a higher kochia emergence (>80%) compared to no tillage or tillage before irrigation (60% emergence). These results indicate that a stale seed bed approach may be more effective in the southern region to stimulate kochia emergence early in the spring with irrigation and a subsequent tillage to exhaust the seed bank prior to late-planted crops such as dry bean (planted in early June) grown in rotation with sugar beet (planted in mid-April).

†Managing Weeds Utilizing an Integrated Cover Crop and Herbicide Management Program. Joshua S. Wehrbein*, Christopher Proctor; University of Nebraska-Lincoln, Lincoln, NE (197)

ABSTRACT

Cover crops may be effective or ineffective at suppressing weeds depending on several factors, including weed population characteristics, environmental factors, and cover crop management practices. The objective of this study was to determine the effect of cover crop planting date, termination date, and herbicide program on weed suppression and corn yield from a systems perspective. A cereal rye and oat cover crop mix was planted at four different times in the fall and terminated at two different times in the spring prior to corn planting. Herbicide treatments included: 1) fall burndown + spring preemergence (PRE) + postemergence (POST), 2) spring PRE + POST, and 3) POST. Cover crop biomass, weed density, weed biomass, and corn yield were measured. Results suggest that use of a residual PRE herbicide was necessary to obtain the highest levels of weed control. Additionally, results showed that the addition of a fall burndown to a spring PRE + POST herbicide program did not provide additional weed control in late spring and summer. Late cover crop termination resulted in less weed biomass than early termination for one of four site-years. Regression analysis further indicated that weed biomass tended to decrease linearly with increasing cover crop biomass production. Corn yield was negatively influenced by cover crop planting date one of two site-years evaluated. These results indicate that cover crops' influence on weed suppression and corn yield is variable and highlights the importance of other traditional methods of weed management.

†Agronomic Practices Influence Soybean Canopy Closure and Waterhemp Suppression. Nikola Arsenijevic*, Nicholas J. Arneson, Maxwel C. Oliveira, Rodrigo Werle; University of Wisconsin-Madison, Madison, WI (198)

ABSTRACT

With the alarming increase of documented herbicide resistance, weed management is becoming very challenging in soybean cropping systems across the North Central United States and beyond. Growers heavily rely on herbicides for weed control and the role of weed suppression by the cultivated crop is often overlooked. Several factors that can influence soybean canopy closure such as planting time, row spacing, tillage, and use of residual soil-applied herbicides, and potentially have an adverse effect on the growth and development of weeds. The objective of this research was to evaluate the influence of the aforementioned factors on soybean canopy closure throughout the growing season. A field experiment was conducted at Arlington Ag Research Station, Wisconsin in 2019. The study was a 2x2x2x2 factorial, considering the effects of early (4/25) and normal (5/17) planting, narrow- and wide-row spacing (0.38 and 0.76 m, respectively), conventional tillage versus no-till, and the presence or absence of a soil-applied herbicide (Fierce MTZ, flumioxazin + metribuzin + pyroxasulfone, 1.16 L ha^{-1}). The study was conducted in a RCBD (16 treatments and 4 replications). Canopy coverage was estimated via Canopeo application by taking photos at 2.4 m above soil level at 7-day increments from planting until when approximately 95% of canopy coverage was attained. Photos were processed in MATLAB, using the Canopeo addon package. Estimated time to 50% canopy coverage (ED_{50}) and grain yield were subjected to ANOVA in RStudio 3.6.1. whereas planting time, herbicide, tillage practice and row spacing were treated as main effects and replication as random. According to ED_{50} results, a significant interaction between tillage and planting time was observed and the main effects of herbicide and row spacing were significant ($P<0.05$). The tillage, early planting and narrow row spacing treatment combination was the first to reach ED_{50}. Planting time was the major factor influencing ED_{50}. In terms of grain yield, there was a significant interaction between planting time and tillage whereas the highest soybean grain yield was observed in the early planted and tilled treatment combination. According to this preliminary results, early planted soybeans can close canopy faster thus better suppressing weeds and enhance yield potential. The data from this research can provide Wisconsin growers with valuable information that can help them maximize the potential of their soybean cropping system. This study will be replicated in 2020.

†Influence of Soil Management Practices on Weed Control, Herbicide Fate and Crop Productivity. Kolby R. Grint*, Rodrigo Werle, Daniel H. Smith, Ryan DeWerff, Maxwel C. Oliveira; University of Wisconsin-Madison, Madison, WI (199)

ABSTRACT

Soil conservation practices such as no-till and cover crops are promoted to reduce soil erosion and improve soil quality in crop production systems. Producers in the Upper Midwest are hesitant to adopt soil conservation practices in corn-soybean production systems due to uncertainty about their effects on crop establishment, crop productivity and overall weed management. In the fall of 2018, experiments were established at two Wisconsin locations (Arlington and Lancaster) to evaluate the influence of soil management practices and herbicide programs on weed control, fate of soil applied herbicides and crop productivity in both corn and soybean (two separate studies). Soil management strategies consisted of conventional tillage, no-till (glyphosate applied at planting) and a fall seeded cereal-rye (*Secale cereale*) cover crop with four different termination strategies: glyphosate applied two weeks prior to crop planting, glyphosate applied at crop planting, glyphosate applied two weeks after crop planting and forage harvest at crop planting. Herbicide programs consisted of preemergence herbicides with soil residual activity (PRE) at planting followed by a postemergence (POST) application or no PRE followed by POST. The study was conducted in a RCBD (4 replications). No significant difference in soybean yield was observed as a result of preemergence herbicide or soil management practice. Corn yields at Arlington, WI were higher in the cover crop treatment terminated two weeks before planting, at crop planting and no-till (p value: <0.05). Corn yield data at Lancaster and herbicide fate are being collected and will be presented at the conference in December 2019. This research will help improve producers' understanding on the effects of soil management practices on crop production and effective management weed management strategies based upon the soil management practice of choice. This research will be replicated in 2020.

†Late Season Control of Horseweed by Glufosinate and Adjuvants. Estefania G. Polli*[1], Frank Sexton[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Exacto, Inc, Sharon, WI (200)

ABSTRACT

Horseweed (*Erigeron canadensis* L.) is one of the most common and troublesome weed species in the United States. Many POST herbicides do not provide effective horseweed control. The use of adjuvants to maximize herbicidal activity is important to obtain a high level of weed control. The objective of this study was to investigate the efficacy of late-season applications of two glufosinate formulations (Liberty 280-SL® and Interline®) on tank-mixtures with AMS and adjuvants (surfactant + humectant) on horseweed fields in Nebraska. Field trials were conducted at the West Central Research and Extension Center's dryland farm near North Platte, NE between June and September of 2019. Horseweed plants (114-116 cm) were sprayed with a six nozzle handheld CO_2-pressurized backpack sprayer calibrated to deliver 140 L ha^{-1} with TT110015 nozzles at 276 kPa. Applications were made using discriminant doses of glufosinate (656 g ai ha^{-1}), surfactant + humectant adjuvants (0.5 or 0.125% v v^{-1}) and AMS (1680 g ha^{-1}). The experiment was conducted two experimental runs using a randomized complete block design with four replications. Visual estimations of injury were recorded 7, 14, 21 and 28 days after treatment (DAT). Ten plants $plot^{-1}$ were marked at the time of application. At 28 DAT, the ten plants were severed at the soil surface and dried at 65 C to a constant weight. Biomass data were subjected to analysis of variance and treatment means were separated using Tukey's least significant difference procedure ($\alpha = 0.05$). The addition of surfactants and humectants in a tank-mixture with glufosinate and AMS did not improved herbicide efficacy of late season applications on horseweed. Further studies are necessary to verify the performance of those adjuvants on glufosinate on other weeds and in other environments as glufosinate efficacy is reported as being variable among different plant species and environmental conditions.

Weed Community Response to Varying Levels of 2,4-D Selection Pressure in 2,4-D-Resistant Soybeans Rotated with Corn. William G. Johnson[1], Travis R. Legleiter[2], Connor L. Hodgskiss*[1]; [1]Purdue University, West Lafayette, IN, [2]University of Kentucky, Princeton, KY (201)

ABSTRACT

The recent development and release of 2,4-D-resistant soybean varieties allows the use of 2,4-D in both soybean and corn. Due to this development it is expected that the use of 2,4-D would increase. Research was conducted to evaluate weed community responses to varying 2,4-D selection pressure over the course of 7 years. This research was conducted at the Throckmorton Purdue Agricultural Center (TPAC) near Lafayette, Indiana. The treatment regimes evaluated were integrated glyphosate with six sites of action (atrazine, S-metolachlor, mesotrione, glyphosate, topramazone, chlormurion, flumioxazin, pyroxasulfone, and fomesafen), 2,4-D reliant with 3 sites of action (atrazine, glyphosate, and 2,4-D), integrated 2,4-D with 7 sites of action (atrazine, S-metolachlor, mesotrione, glyphosate, topramazone, chlormurion, flumioxazin, pyroxasulfone, and 2,4-D), and fully integrated with 8 sites of action (atrazine, S-metolachlor, mesotrione, glyphosate, topramazone, chlormurion, flumioxazin, pyroxasulfone, glusoinate, and 2,4-D in soybean years). Of the 4 herbicide strategies listed, soil residuals were utilized for both corn and soybean years, except for the 2,4-D reliant strategy, which only utilized a residual herbicide in odd years when corn was grown. From 2016 to present, the 2,4-D reliant strategy resulted in at least 128 total weeds m^{-2} , while the next highest herbicide strategy never reached above 2.75 total weeds m^{-2} prior to a POST application. Of the total weeds within the 2,4-D reliant herbicide strategy from 2016 to present, at least 86% were grass species. The 2,4-D reliant herbicide strategy had higher densities of dicot species in soybean years compared to the other 3 strategies. Total species richness was also higher in the 2,4-D reliant strategy resulting in an average of at least 1.8 species up to 8.0 species. The other herbicide strategies never exceeded an average of 1.8 species in any year. Although the 2,4-D reliant strategy contained primarily grass species, the diversity of the weed population was evenly split between grasses and dicots with neither type exceeding more than 60% of the total species diversity. This research indicates that integrating multiple sites of action into a herbicide management plan would help reduce total weed densities and total species richness. Furthermore, corn yields were reduced in years 3 and 5 by 2,4-D treatments by at least 7% compared to the fully integrated treatment. In 2019 corn yield was only reduced in the Integrated 2,4-D treatment resulting in a 11.5% yield reduction. Therefore, producers need to use these management practices even though glyphosate, 2,4-D, and atrazine may provide high levels of weed control in the early years of adoption as 2,4-D-resistant soybeans are commercialized.

†The Challenge Associated with Novel Palmer Amaranth Infestations in the Upper Midwest. Felipe de Andrade Faleco*, Maxwel C. Oliveira, David Stoltenberg, Rodrigo Werle; University of Wisconsin-Madison, Madison, WI (202)

ABSTRACT

The increased number of detected Palmer amaranth (*Amaranthus palmeri*) infestations in Wisconsin and across the upper Midwest is a major concern. Greenhouse experiments were established to investigate the resistance level of a Palmer amaranth population detected in Wisconsin in 2018 compared to two established populations from western Nebraska to preemergence (PRE) and postemergence (POST) herbicides commonly used in corn and soybean. In the PRE study, treatments were atrazine (2.242 kg ai ha^{-1}), mesotrione (0.27 kg ai ha^{-1}), metribuzin (0.525 kg ai ha^{-1}), sulfentrazone (0.280 kg ai ha^{-1}) and S-metolachlor (1.785 kg ai ha^{-1}) applied at 0.5x, 1x and 3x label rates, and a nontreated control. Herbicides were sprayed using a single-nozzle spray chamber with AI9502EVS nozzles calibrated to deliver 140 L ha^{-1} of spray solution. The study was conducted in a CRD with 4 replications and 2 experimental runs. At 25 days after treatment (DAT), the number of established plants and aboveground biomass per experimental unit were recorded. In the POST study, treatments consisted of: glyphosate (0.864 kg ae ha^{-1} + 2.184 kg ha^{-1} AMS), imazethapyr (0.072 kg ai ha^{-1}+ 2.352 kg ha^{-1} AMS + 0.868 L ha^{-1} COC), atrazine (2.242 kg ai ha^{-1} + 1.17 L ha^{-1} COC), lactofen (0.218 kg ai ha^{-1}+ 0.504 kg ha^{-1} AMS + 0.58 L ha^{-1} COC), mesotrione (0.106 kg ai ha^{-1} + 1.428 kg ha^{-1} AMS + 0.7 L ha^{-1} COC), glufosinate (0.654 kg ai ha^{-1} + 2.242 kg ha^{-1} AMS), 2,4-D (0.8 kg ae ha^{-1}) and dicamba (0.565 kg ae ha^{-1}) applied at 1x and 3x label rates, and a nontreated control. Treatments were applied when plants reached 5 to 10 cm using the aforementioned spray chamber and calibration settings with TP8002EVS nozzles. The synthetic auxin herbicides were sprayed using a CO_2-pressurized backpack spray boom with TTI 110015 nozzles using the aforementioned calibration settings. The study was conducted in a CRD with 8 replications and 2 experimental runs. At 21 DAT, visual evaluation was taken on a scale from 1 (dead) to 10 (healthy), and the aboveground biomass per experimental unit was recorded. Palmer amaranth populations were considered resistant to each treatment if more than 50% of treated plants across both experimental runs had VE $\geq$ 7. According to our results, atrazine did not provide satisfactory control in PRE emergence applications. Reduced PRE rates (0.5X) resulted in lower Palmer amaranth control for some herbicides. All populations tested in the POST emergence screenings were found to be resistant to imazethapyr (1x and 3x), two populations to glyphosate and atrazine (1x), and one population to atrazine (3x). The Wisconsin population was resistant to these 3 herbicides. Glufosinate resulted in the most satisfactory POST control. This study indicates that novel infestations of Palmer amaranth are likely to be resistant to herbicides.

†Herbicide Drift Exposure Leads to Reduced Herbicide Sensitivity in *Amaranthus* spp. Bruno C. Vieira*[1], Keenan L. Amundsen[2], Rodrigo Werle[3], Joe D. Luck[2], Todd Gaines[4], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Wisconsin-Madison, Madison, WI, [4]Colorado State University, Fort Collins, CO (203)

ABSTRACT

While the introduction of herbicide-tolerant crops provided growers new options to manage troublesome weed species, the widespread adoption of these herbicides increased the risk of application off-target movement towards sensitive areas. The impact of herbicide drift towards sensitive crops is extensively investigated in the literature, however scarce information is available on the consequences of herbicide drift towards other plant communities in neighboring agricultural landscapes. Troublesome weed species are often abundant in field margins and ditches surrounding agricultural landscapes, and herbicide drift exposure could be detrimental to long-term weed management as numerous weed species have evolved herbicide resistance following recurrent applications of low herbicide rates. The objective of this study was to evaluate whether glyphosate, 2,4-D, and dicamba spray drift exposure could result in herbicide-resistant Amaranthus spp. Palmer amaranth and waterhemp populations (P0) were recurrently exposed to glyphosate, 2,4-D, and dicamba drift from fine and ultra coarse sprays in a wind tunnel over two generations. Survivors of each treatment were enclosed in pollination tents to ensure cross-pollination exclusively within specific treatments. Seeds from each treatment were collected at maturity and used for the subsequent round of herbicide drift selection to establish P1 and P2 progenies. Following recurrent selection, P0 and P2 progenies (herbicide*population*nozzle treatments) were subjected to glyphosate, 2,4-D, and dicamba dose-response studies (respective to herbicide drift selection treatment). Plant aboveground biomass was collected at 30 DAT and oven dried at 65 C to constant weight. A non-linear regression model was fitted to dry weight data in response to herbicide dose using the drc package in R software. Effective doses to obtain 90% biomass reduction (ED_{90}) were reported. The study results indicate that herbicide drift exposure rapidly selected for Amaranthus spp. biotypes with reduced herbicide sensitivity over two generations. Sensitivity shifts (ED_{90}) up to 3.3, 2.2, and 2.4-fold were reported for waterhemp populations exposed to glyphosate, 2,4-D, and dicamba drift, respectively. The Palmer amaranth population from Perkins County had reduced 2,4-D sensitivity up to 2.5-fold following 2,4-D drift exposure over two generations. This Palmer amaranth population also had a 54.7-fold sensitivity shift for glyphosate following glyphosate drift exposure, indicating that individuals with a major glyphosate resistance mechanism were already present within the population prior to glyphosate drift selection. Preventing the establishment of resistance prone weeds on field margins and ditches is an important management strategy to delay the evolution of herbicide resistance. Weed management programs should consider strategies to mitigate near-field spray drift, and suppress troublesome weed populations on field borders in agricultural landscapes.

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

†Is Waterhemp More Difficult to Control Following a Sublethal Glufosinate Application? Jesse A. Haarmann*, Bryan G. Young, William G. Johnson; Purdue University, West Lafayette, IN (204)

ABSTRACT

Failure to control weeds with a postemergence (POST) herbicide application often results in the need to make a respray application. Planned sequential POST programs are also being used to control large weeds. However, research is lacking on how the level of injury from the initial application affects the efficacy of a respray or sequential herbicide. The objective of this research was to determine how the level of injury from a prior herbicide application affects efficacy of a respray application. A greenhouse bioassay was conducted to model waterhemp response to respray herbicide applications. Waterhemp plants were sprayed with glufosinate at rates of 0, 100, 150, 200, 250, or 300 g ai ha^{-1} to create a gradient of herbicide injury. A respray application of either glufosinate, fomesafen, lactofen, dicamba, 2,4-D, or no herbicide was applied 7 days later. Initial glufosinate rate and the amount of green tissue remaining (green area) were used to create models that predict efficacy of the respray herbicide based on the level of injury from the initial application. Models based on the initial rate of glufosinate and green area both indicated that respray treatments of lactofen, fomesafen, and dicamba had 1.3 to 2.3 fold greater activity than glufosinate on injured plants. Fomesafen as a respray treatment had the greatest activity in both models with 1.4 to 2.3 fold greater activity on injured waterhemp than respray treatments of 2,4-D, dicamba, lactofen, and glufosinate. These results indicate that respray herbicide efficacy following an initial application of glufosinate is greater on heavily injured plants than on non-injured or lightly injured plants and that fomesafen controls injured waterhemp more effectively than other respray treatments.

†Overwinter Survival of Johnsongrass Rhizomes in Nebraska and Kansas. Samantha D. Isaacson*; University of Nebraska Lincoln, Lincoln, NE (205)

ABSTRACT

Johnsongrass (Sorghum bicolor), can reproduce asexually through its rhizomes. Johnsongrass can be difficult to control and many attribute its hardiness to its rhizomes. But little is known about how well these rhizomes survive in midwestern states. A Johnsongrass experiment in 2015/2016 which failed to produce viable rhizomes caused us to question if rhizome viability has been overestimated in Nebraska and Kansas. This experiment aimed to understand if rhizomes significantly contribute to the Johnsongrass life cycle in Nebraska and Kansas. It was hypothesized that rhizomes would survive the winter better in Manhattan, KS than in Lincoln, NE. The experiment also tested if different populations produced more resilient rhizomes. The study also addresses if the depth of the rhizome effects viability.

In 2017 to 2018, rhizomes were collected from six different populations from Nebraska and Kansas in early November and partitioned into experimental units. Each experimental unit was composed of one to three rhizomes with a total of fifteen nodes. In a randomized complete block design, the experimental units were randomly allocated to test the fresh viability of the rhizomes, the overwintering viability of the rhizomes in Lincoln, NE and Manhattan, KS, and the summer viability in Lincoln and Manhattan.

In order to test fresh viability, the rhizomes were planted in a greenhouse and emergence was recorded. In order to test overwintering viability of the rhizomes, the experimental units were planted in mesh baskets at four inches deep in field sites in Lincoln, NE and Manhattan, KS. The rhizomes were planted in November, removed in mid-April, cleaned, planted in the greenhouse, and emergence was recorded. In order to test summer emergence, the rhizomes were similarly planted in baskets in November and left in the fields until August. Emergence was recorded in the field and later in the greenhouse. Rhizomes were removed in August and planted in the greenhouse.

The following year, one element was added on: depth. The number of experimental units testing overwintering and summer viability were doubled. Half of the rhizomes were planted at four inches deep and the rest were planted at 8 inches deep. This will be repeated in 2019-2020.

There was a steep drop off in viability in both Nebraska and Kansas from November to April, and a further drop off in viability from April to August. 98% of the fresh viability experimental units had at least one viable node. Over the two years, 31.8% of the nodes were viable in November. This dramatically dropped off to only 1.9% by April and was significantly reduced to 0.38% by August. Due to a large number of zeros in our dataset, it has been impossible to detect differences between Nebraska and Kansas viability and the effect of planting depth.

In conclusion, the viability of rhizomes in Nebraska and Kansas are dramatically reduced by harsh winters and further reduced in the summer months. Rhizomes do not overwinter as well in Nebraska and Kansas as previously suspected.

Symposium: The What, How, and Why of Dicamba Tank Clean-Out

Abstracts were not requested for symposia and were submitted on a voluntary basis. The following presentations did not submit an abstract:

Sprayer Hygiene and Dicamba – Season Tickets Versus Single Game. Matt Faletti*, Jim Reiss; Precision Labs, Waukegan, IL (206)

Considerations for Sprayer System Cleanout. Chris Bursiek*; John Deere, Des Moines, IA (207)

Potential Impact of Dicamba Tank Contamination on Non-Dicamba Tolerant Soybean. Greg Kruger*, Jeffrey A. Golus, Milos Zaric; University of Nebraska-Lincoln, North Platte, NE (208)

Mississippi State Weed Science Dicamba Tank Clean-Out Research. Dan Reynolds*; Mississippi State University, Starkville, MS (209)

Tank Cleaners Minimize Dicamba Contamination of Spray Equipment. Reid J. Smeda*, Jerri Lynn Henry; University of Missouri, Columbia, MO (210)

Out of Sight Out of Mind: Improving Spray Boom Hygiene in the Dicamba Age. Nick J. Fleitz*; Pentair Hypro, New Brighton, MN (212)

Tank Cleaner Research to Remove Auxin Herbicide Residues from Sprayers. Tom Mueller*; University of Tennessee, Knoxville, TN (211)

ABSTRACT

This report details our efforts to provide an objective assessment of commercially available tank cleaning agents to remove residues of dicamba or 2,4-D from simulated spray tank components. An overview of the method consists of applying a known amount of herbicide to simulated tank parts (in this study EPDM sheets which would be comparable to hose material used in some commercial spray equipment), allowing that material to dry, removing them with various tank cleaner treatments, and quantifying the difference using chemical assay. Preliminary studies showed that physically abrading the EPDM surface altered pesticide adherence to the EPDM sheet. For this study we conducted separate studies with dicamba or 2-4,D (both at normal field use rates) plus glyphosate at 1.1 kg ae ha^{-1} in the spray mixture of 94 L ha^{-1}. The tank parts were placed into a fume hood and 1.0 mL of the spray solution was added in 16 to 24 drops to the top of each tank part. These parts were then allowed to dry in a fume hood for approximately 12 hours at room temperature. Tank cleaners were prepared by adding 0.25% v v^{-1} per label instructions (this was 1.0 ml into 400 mL). Each 5*10 cm EPDM sheet was inserted in 400 mL of each respective tank cleaner for 5 seconds. An aliquot of the tank cleaner rinsate water was diluted for later analysis on LCMS for each respective herbicide. Another type of data measured was the pH of the tank cleaner solution. There were statistically different pHs and recoveries from the various tank cleaners. All treatments were also compared to a control treatment where the initial 1.0 mL of herbicide mixture was placed directly into a 1000 mL bottle as a comparison. For dicamba, the order of most effective tank cleaners was FS Rinseout ≥ Ammonia = water alone > Purus = All Clear = Neutralize = Wipeout = Innvictis. For 2,4-D choline salt the order starting with most effective was FS Rinseout = Ammonia = water only ≥ Innvictis > Purus = All Clear = Neutralize = Wipeout. These preliminary data indicated only minor benefits of using the commercial tank cleaners, although further studies on different tank components still need to be conducted.

Papers: Agronomic Crops II - Soybeans

Do pH Modifiers Affect the Efficacy of Glyphosate + Dicamba Tank-Mixes? Nicholas R. Steppig[1], Bryan G. Young[1], Nathan H. Haugrud[2], Michael H. Ostlie[3], Joseph T. Ikley*[2]; [1]Purdue University, West Lafayette, IN, [2]North Dakota State University, Fargo, ND, [3]North Dakota State University, Carrington, ND (213)

ABSTRACT

Off-target movement of dicamba has become increasingly scrutinized since the introduction of dicamba-tolerant soybean in the United States in 2017. Volatility has been one of the most researched pathways of off-target movement of dicamba, and research has shown that low pH spray solutions increase volatility of dicamba. One common practice that lowers the spray solution pH is the addition of glyphosate, which is common for many dicamba applications in dicamba-tolerant soybean. Label changes for newly formulated dicamba products indicate that pH modifiers should be added to the spray tank if spray solution pH is lower than 5. Raising the pH of the spray solution above 5 should help reduce volatility, but there is little knowledge of the effect on herbicide efficacy when raising the pH of dicamba + glyphosate spray solutions. The objective of this research was to examine the effect on herbicide efficacy of glyphosate + dicamba tank-mixes by adding pH modifiers to the spray solution. Trials were established at the Davis Purdue Agricultural Center (DPAC) near Farmland Indiana, at the Carrington Research and Extension Center in Carrington North Dakota, and a site near Hillsboro North Dakota in 2019. Treatments consisted of adding one of three pH modifiers to spray solutions containing tank-mixes of the BAPMA salt of dicamba + a potassium salt of glyphosate (560 + 1260 g ha^{-1} and 280 + 630 g ha^{-1}). The pH modifiers were Ndemand 88 at 2.34 L ha^{-1}, Ndemand Entourage K at 2.34 L ha^{-1}, and Linkage at 1 % v v^{-1}. At each dicamba + glyphosate rate, there was a no-pH modifier control. The spray solution pH was measured prior to and after adding each pH modifier. Herbicide efficacy was rated 14 and 28 days after treatment (DAT) at each site. The addition of the pH modifiers increased the spray solution pH anywhere from 0.2 to 2.1 units depending on product and herbicide rate. The efficacy at 28 DAT indicate that the addition of pH modifiers have a variable effect on herbicide efficacy depending on product and weed species. The addition of a pH modifier did not affect efficacy on redroot pigweed (*Amaranthus retroflexus*) or common lambsquarters (*Chenopodium album*) at either dicamba + glyphosate rate. Waterhemp (*Amaranthus tuberculatus*) control was not affected by the addition of a pH modifier at the low rate of dicamba + glyphosate, however the addition of Ndemand Entourage K increased waterhemp control from 70% to 81% at the high rate of dicamba + glyphosate compared to no pH modifier. Conversely, the addition of any of the pH modifiers reduced green foxtail (*Setaria viridis*) control at the low rates of dicamba + glyphosate. Results indicate that pH modifiers do increase spray solution pH which will help reduce dicamba volatility, however the effect on dicamba + glyphosate efficacy may be difficult to predict depending on product choice and target weed species.

Understanding the Role of Weather in Off-Target Dicamba Movement to Improve Application Practices. Mandy Bish*, Kevin Bradley; University of Missouri, Columbia, MO (214)

ABSTRACT

Off-target dicamba movement (OTM) can be generalized in two categories: movement that occurs at the time of application (primary) and movement that occurs after application (secondary). Weather has long been associated with both types of OTM; however, not all role(s) of weather are fully understood. For this reason, weather data were collected in 2018 and 2019 from 29 weather stations equipped with identical instrumentation to monitor air temperatures and temperature inversions at heights relevant to ground applications. Weather stations were located in Arkansas, Illinois, Indiana, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee. Twenty-seven stations were equipped with anemometers for wind measurements and 26 with probes for relative humidity readings. Overnight inversions were identified at all sites; however, preliminary analyses of June data suggest sunset is not always a reliable indicator of the time an inversion will initiate. Wind speed reduction in the hours leading up to inversion formation may serve as a more reliable predictor for some locations. For the month of June, average daily air temperatures peaked near 3:00 PM in most mid-South locations, and average relative humidity dropped to the lowest percentage near the same time. Average daily air temperatures across locations peaked between 26 and 31°C. Lowest relative humidity readings ranged from 50 to 63 percent. Of the 27 locations with wind measurements, only one site had daily averages that peaked above 4.5 m s^{-1}. Lack of winds for particle dispersal combined with afternoon conditions that favor volatility may contribute to the higher incidences of secondary movement observed in some geographies when compared to others. Potential implications of these weather data on primary and secondary movement will be discussed.

Dicamba Volatilization from Soybean Leaves and Bare Soil. Donald Penner*, Christine Vandervoort, Jan Michael; Michigan State University, East Lansing, MI (215)

ABSTRACT

Following postemergence applications of a volatile herbicide such as dicamba, volatilization may occur prior to the herbicide reaching the target site as well as after it has been deposited on the leaf or soil. This report is focused on the latter. Using a previously described bioassay system, greenhouse experiments were conducted on bare soil and soybean plants using 0.84 kg ha^{-1} dicamba. Three formulations of were evaluated, Clarity, Engenia, and Xtendimax. Evaluation of potential vapor injury to tomatoes spanned 6 days from date of treatment application (DAT). It appeared that volatility was greater from soybean leaves than from the soil surface.

Employing a similar set up, the physical/chemical assay spanned 5 DAT, in which vapor was captured daily for 24 hours with polyurethane foam plugs (PUF). These were extracted with methanol, and the dicamba, diglycolamine (DGA), and BAMPA concentration determined by HPLC/mass spectrophotometric analysis.

The physical/chemical assay found the highest level of dicamba resulted from the Clarity formulation and it was statistically different from the other 2 formulations. The bioassay showed a similar degree of injury for all 3 formulations. Perhaps the dicamba application rate in the bioassay was too high to show differential among formulations.

Lessons from Two Years of Dicamba Off-Target Movement Research in Wisconsin. Rodrigo Werle*[1], Maxwel C. Oliveira[1], Ryan Rector[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]Bayer Crop Science, Saint Louis, MO (216)

ABSTRACT

The widespread occurrence of herbicide-resistant broadleaf weeds has led to a rapid adoption of the novel dicamba-tolerant soybean trait (Xtend technology; DT soybean) and POST-emergence application of registered dicamba products. Non-DT soybean varieties are extremely sensitive to dicamba and symptomology caused by dicamba off-target movement (OTM) has become a major concern regarding this technology. A series of low-tunnel studies designed to evaluate secondary OTM and large-scale OTM trials were conducted at UW-Madison Arlington Agricultural Research Station, near Arlington, Wisconsin in 2018 and 2019. Some of the treatments evaluated in the low-tunnel trials were not legally approved tank-mix partners or commercialized products. From the low-tunnel trials we have learned that tank-mix partners influence secondary dicamba OTM. Moreover, the addition of MON-51817 to the dicamba plus K-salt of glyphosate tank-mix reduced dicamba symptomology due to secondary OTM. From the large-scale field trials, we learned that dicamba symptomology in non-DT soybean followed wind direction during and after application (0-48 hours). Soybean dicamba symptomology decreased as distance from treated area increased whereas minor to no symptomology was observed after 35 m downwind from the treated area. The addition of MON-51817 to the dicamba plus K-salt of glyphosate in the 2019 field experiment led to reduced visual symptomology due to secondary OTM (tarped area during and shortly after application [30-60 minutes] showed less symptomology compared to the non-tarped areas evaluated) compared to 2018. Multispectral aerial imagery collected 4-5 weeks after application in 2019 accurately mapped downwind dicamba symptomology in the non-DT soybean. Results from these studies highlight the importance of proper tank-mix in order to reduce dicamba OTM, the value of following the label restrictions and not spraying when sensitive crops are present downwind, and the potential for using aerial imagery to document dicamba symptomology to non-DT soybeans.

Dimetric Charged: A New Option for Burndown and Residual Weed Control. Ryan J. Edwards*[1], Greg K. Dahl[1], Eric P. Spandl[1], Mark A. Risley[1], Annie D. Makepeace[2]; [1]Winfield United, River Falls, WI, [2]Winfield United, Arden Hills, MN (217)

ABSTRACT

Dimetric® Charged, a combination herbicide containing a Group 5 (metribuzin) and a Group 14 (flumioxazin), is a new option for burndown and residual weed control. Field trials conducted in 2018 and 2019 show an increased knockdown and residual control of tough to control weed like Palmer amaranth (*Amaranthus palmeri*), horseweed (*Conyza canadensis*), common waterhemp (*Amaranthus tuberculatus*) and others. When combined with other POST applied herbicides and high surfactant oil concentrate (HSOC) adjuvants, Dimetric® charged provides longer lasting control.

Preplant Burndown Weed Control with Elevore Herbicide with Arylex Active. Kristin Rosenbaum*[1], Larry Walton[2], Joe Armstrong[3]; [1]Corteva Agriscience, Coffey, MO, [2]Corteva Agriscience, Tupelo, MS, [3]Corteva Agriscience, Indianapolis, IN (218)

ABSTRACT

Elevore® is a herbicide developed by Corteva Agriscience for the U.S. pre-plant herbicide market segment for control of horseweed [*Conyza canadensis* (L.) Cronq] and other problematic broadleaf weeds. It contains Arylex™ active (halauxifen-methyl), a novel synthetic auxin (WSSA group 4) herbicide from the "arylpicolinate" chemical class. Elevore is an SC formulation with a use rate of 1.0 fl oz product A^{-1} (5 g ae ha^{-1}) and is labeled for use prior to soybean, corn, and cotton planting. The Elevore label allows for pre-plant applications 14 days prior to planting of soybean and corn. Field research was conducted from 2015 to 2019 at over 100 locations across the U.S. to determine the efficacy of Elevore applied in the fall and spring to horseweed, including glyphosate-resistant biotypes, and other common weeds prior to planting corn and soybean. Elevore was compared to competitive standards when applied with glyphosate and in tank mixes with glyphosate + 2,4-D low volatile ester (LVE) herbicide. Applied at 5 g ae ha^{-1} in combination with glyphosate at 1120 g ae ha^{-1}, Elevore demonstrated similar to or better control of horseweed when compared to Liberty (glufosinate) at 542 g ae ha^{-1}, Clarity (dicamba) at 280 g ae ha^{-1} + glyphosate 1120 g ae ha^{-1}, and Sharpen (saflufenacil) at 37.5 g ai ha^{-1} + glyphosate at 1120 g ae ha^{-1}. Elevore provides growers with an alternative mode of action for many difficult to control, pre-plant burndown broadleaf weeds such as horseweed and henbit (*Lamium amplexicaule* L.).

Investigating the Influence of Soybean Variety, Herbicide Rate, and Preplant Timing, on Soybean Response to Soil Applications of Trifludimoxazin and Trifludimoxazin Plus Saflufenacil. Nicholas R. Steppig*[1], Derek M. Whalen[2], Bryan G. Young[1]; [1]Purdue University, West Lafayette, IN, [2]BASF Corporation, Seymour, IL (219)

ABSTRACT

Trifludimoxazin is a new PPO-inhibiting herbicide currently being developed by BASF Corporation for commercialization as a preplant herbicide for use in soybean. The combination of trifludimoxazin with saflufenacil may be used to improve weed control spectrum and to provide additional soil-residual weed control. Previous research has demonstrated that PPO-inhibiting herbicides have the potential to cause soybean injury when applied prior to planting; however, no published research exists examining the effect of trifludimoxazin or trifludimoxazin plus saflufenacil when applied in this manner. Therefore, the objective of this research was to investigate the effect of soybean variety, trifludimoxazin rate, the addition of saflufenacil to trifludimoxazin, and timing of application of these two herbicides in soybean. Field trials were conducted in 2018 and 2019 at the Throckmorton Purdue Agriculture Center (TPAC), Pinney Purdue Agriculture Center (PPAC), and Davis Purdue Agriculture Center (DPAC) utilizing a four factor factorial, randomized complete block design with four replications. Factors included soybean variety (Asgrow 39X7 and HiSoy 39X70), trifludimoxazin rate (0, 6.25, 12.5, and 25 g ai ha^{-1}) with and without saflufenacil at a fixed 1:2 ratio, and application timing (0, 7, 14, and 28 days prior to planting). Soybean injury at 4 weeks after planting was <10% for all treatments applied 14 or 28 days prior to planting, and <5% in all instances except for the treatment containing 25 g ha^{-1} of trifludimoxazin plus saflufenacil in the Asgrow variety at PPAC in 2018. The greatest soybean injury was observed at PPAC in 2019, where applications of 25 g ha^{-1} of trifludimoxazin plus saflufenacil at planting to both soybean varieties resulted in up to 40% injury at 4 WAP and 27% soybean yield loss. The PPAC soil type represents a coarse textured soil compared with the other two research sites. These results suggest that applications of trifludimoxazin alone, and in combination with saflufenacil, are safe to the soybean varieties evaluated when applied at least 14 days prior to planting, regardless of soil type. However, when applying these herbicides at either 7 days prior to planting or at planting, the likelihood of soybean injury increased depending on a combination of herbicide rate applied, soybean variety, soil characteristics, and environmental factors. Yield loss following this injury was only observed at one site-year, following applications of the highest rate of trifludimoxazin plus saflufenacil, indicating that although some injury may be observed as herbicide applications are made closer to planting, the risk for soybean yield loss following these applications is relatively low.

Enlist E3 Soybean Tolerance and Weed Control Programs. David Simpson*; Corteva Agrisciences, Indianapolis, IN (220)

ABSTRACT

First sales of Enlist E3™ soybean seed occurred in 2019 enabling the use of Enlist™ weed control system to control glyphosate susceptible and resistant weeds in U.S. soybean fields. Enlist E3 soybean contains a single molecular stack of *aad-12*, *pat* and *2mepsps* genes which conveys tolerance to 2,4-D choline, glufosinate and glyphosate. Enlist Duo® with Colex-D® technology is a 0.95:1 premix containing 2,4-D choline 195 g ae L^{-1} and glyphosate 205 g ae ha^{-1} with a recommended use rate of 1640 and 2185 g ae ha^{-1}. Enlist One® with Colex-D Technology contains 2,4-D choline 456 g ae L^{-1} with the recommended use rate being 800 to 1065 g ae ha^{-1}. Enlist One should be tank mixed with either glyphosate or glufosinate for control of grass and broadleaf weeds. The recommended spray volume for Enlist Duo or Enlist One plus glyphosate is 94 to 187 L ha^{-1}. Both Enlist One and Enlist Duo contain Colex-D Technology that results in less potential for physical drift and near zero volatility of 2,4-D. When the Colex-D Technology is matched with approved nozzles, the percentage of driftable fines can be reduced by 90% compared to traditional 2,4-D formulations and nozzles. In contrast to dicamba products, the volatility potential for Enlist One and Enlist Duo herbicides is not affected by the addition of ammonium sulfate, glyphosate or glufosinate. For optimum weed control and resistance management, Corteva recommends starting clean prior to planting, apply two effective site of action residual herbicides prior to crop emergence and then apply either Enlist Duo or Enlist One plus glufosinate or glyphosate when weeds are four inches or less. Residual herbicides approved for use with Enlist One and Enlist Duo can be included in the postemergence application to extend the residual control of *Amaranthus* species. Only tank mix with products that are listed on www.enlisttankmix.com website for Enlist One and Enlist Duo. A sequential postemergence application of Enlist Duo or Enlist One plus glyphosate or glufosinate can be applied with a minimum of 12 days between applications. In 2019, over million acres of Enlist E3 soybean were treated with either Enlist Duo or Enlist plus glufosinate or glyphosate with no off-target movement issues reported to Corteva. Since 2013, the programs of preemergence residual herbicides followed by Enlist Duo or Enlist One plus glufosinate or glyphosate has provided greater than 90% weed control in university soybean trials across the US. Enlist E3 soybean with the Enlist weed control system provide growers with options for controlling glyphosate resistant broadleaf weeds.

Weed Control and Crop Tolerance with Glu-L™, a Resolved Isomer of Glufosinate, in Glufosinate Resistant Cotton and Soybean. Thomas A. Hayden*[1], Brian Green[2]; [1]AgriMetis, LLC, Owensboro, KY, [2]AgriMetis, LLC, Lutherville, MD (221)

ABSTRACT

Racemic glufosinate, a 50:50 mixture of D-glufosinate and L-glufosinate controls weeds in glufosinate tolerant soybean, cotton, corn and canola. Glu-L™ (AgriMetis LLC), an enantiomerically enriched L-glufosinate isomer, was evaluated in two formulations, F47 and F50, for weed control and crop tolerance in glufosinate tolerant cotton and soybean and compared to racemic glufosinate. The objective was to determine if the 280 g L^{-1} Glu-L formulations would provide equal weed control and crop tolerance at 50% of the 280 g L^{-1} racemic glufosinate product use rate.

Field experiments were conducted at thirteen locations for POST-emergence weed control efficacy in soybean and six locations for soybean tolerance in 2019. Soybean efficacy trials were conducted with racemic glufosinate at 296, 592, 890, and 1190 g ai ha^{-1} and two formulations of Glu-L™, F47 and F50 each at 148, 296, 445 and 595 g ai ha^{-1}. Ammonium sulfate (AMS) was added to all treatments in midwestern locations. Efficacy trials were conducted as a randomized complete block design with four replications. Cotton POST-emergence efficacy trials were conducted at nine locations and POST-emergence tolerance trials were conducted at three locations in 2019. Cotton and soybean tolerance trials were conducted as a split plot design with five varieties as the main plot and ten herbicide treatments as the subplots. Herbicides were 280 g L^{-1} racemic glufosinate at 592, 1190 and 2380 g ai ha^{-1} and 296, 595 and 1190 g ai ha^{-1} for 280 g L^{-1} Glu-L™F47 and 280 g L^{-1} Glu-L™F50 and a nontreated check. AMS was added to all herbicide treatments and applications were made at V1 or V3 timings.

Weed control across all broadleaf species was equal for racemic glufosinate and Glu-L™F50 at equivalent rates of L-glufosinate at 7 and 14 DAA. Glu-L™F-47 provided overall broadleaf control equal to racemic glufosinate and Glu-L™F50 except at the below label 148 g ai ha^{-1} rate at 14 DAA. Palmer amaranth (*Amaranthus palmeri*), tall waterhemp (*Amaranthus tuberculatus*) and horseweed (*Erigeron canadensis*) control at 7 and 14 DAA was equal for racemic glufosinate, Glu-L™F47 and Glu-L™F50. Overall grass control was equal with racemic glufosinate and Glu-L™F50 at equivalent L-glufosinate rates. Glu-L ™F47 provided equal grass control to Glu-L™F50 and racemic glufosinate except for the below label 148 g ai ha^{-1} rate at 7 DAA. Goosegrass (*Elusine indica*) and large crabgrass (*Digitaria sanguinalis*) control was equal with racemic glufosinate, Glu-L™F47 and Glu-L™F50.

Response of cotton varieties from racemic glufosinate was 10-35% greater in Georgia, 0-8% greater in North Carolina and 2-8% greater in Texas than Glu-L™ F47 and Glu-L™ F50 at label rates of equivalent amounts of L-glufosinate. Response of soybean varieties from racemic glufosinate was 5-20% greater in South Carolina and 7-36% greater in Minnesota than from equivalent label rates of Glu-L™F47 and Glu-L™F50. Racemic glufosinate caused 0-10% greater soybean injury at the other locations.

At proposed label rates of 296 and 445 g ai ha^{-1}, Glu-L™F47 and Glu-L™F50 provided grass and broadleaf control equal to 592 and 890 g ai ha^{-1} racemic glufosinate at equal L-glufosinate rates, with less or equal cotton or soybean response.

Herbicide-Resistant Palmer Amaranth and Common Waterhemp in Kansas.

Vipan Kumar*, Rui Liu, Natalie K. Aquilina, Taylor Lambert, Phillip W. Stahlman; Kansas State University, Hays, KS (222)

ABSTRACT

Herbicide-resistant (HR) pigweeds, including Palmer amaranth (*Amaranthus palmeri*) and common waterhemp (*Amaranthus tuberculatus*) have become increasing concern for Kansas growers. In 2014, a field survey was initiated to collect seeds of Palmer amaranth from agronomic crops across Kansas to determine the frequency and distribution of HR Palmer amaranth. The main objectives of this research were to (1) determine the resistance frequency (as percent resistance within a population) in 16 Palmer amaranth populations from Kansas soybean fields to discriminate-dose of glyphosate, 2,4-D, glyphosate + 2,4-D choline premix (Enlist Duo®), dicamba, glufosinate, fomesafen; and (2) characterize the response of two selected populations (KW2 and PR8) from Kiowa and Pratt Counties, KS to 2,4-D, glyphosate, chlorsulfuron, atrazine, and mesotrione in dose-response assays. For objective 1, seedlings of each selected population were grown in 5- by 5-cm size cells within a plastic tray (total 50 cells tray^{-1}) filled with a commercial potting mix in a greenhouse at Kansas State University Agricultural Research Center-Hays (KSU-ARCH). Actively growing seedling (7- to 9-cm tall) were separately treated with discriminate dose of glyphosate (1260 g ha^{-1}), 2,4-D (870 g ha^{-1}), glyphosate + 2,4-D choline (1071 + 1008 g ha^{-1}), dicamba (560 g ha^{-1}), glufosinate (655 g ha^{-1}), and fomesafen (352 g ha^{-1}). For objective 2, whole plant dose-response assays were conducted on two putative (KW2 and PR8) and a known susceptible (SUS) Palmer amaranth populations using various doses of 2,4-D, glyphosate, chlorsulfuron, atrazine, and mesotrione herbicides . Dose-response assays were conducted in a randomized complete block design in factorial arrangement of treatments (populations by herbicides) with 12 replications. Based on percent survival data collected at 10 days after treatment (DAT), resistance to glyphosate, 2,4-D, glyphosate + 2,4-D choline, dicamba, and glufosinate was observed in 16, 3, 1, 8, and 1 populations (out of 16 total) with resistance frequency of 48 to 92%, 20 to 30%, 20%, 20 to 26%, and 50% respectively. None of the tested populations showed resistance frequency of > 18% with a discriminate dose of fomesafen herbicide. Whole plant dose-response studies indicated the KW2 population had 3.0-, 2.3-, 5.8-, and 8.4-fold less sensitivity to 2,4-D, chlorsulfuron, atrazine, and mesotrione, respectively, compared to SUS population. In contrast, the PR8 population was 2.0-, 8.6-, 10.6-, 3.7-, and 2.8-fold less sensitive to 2,4-D, glyphosate, chlorsulfuron, atrazine, and mesotrione, respectively, compared to SUS population. Overall, these results suggest that resistance to commonly used herbicides (glyphosate, 2,4-D, and dicamba) is evident in Palmer amaranth populations in Kansas soybean fields. Growers should adopt diversified weed control methods to tackle the increasing problem of HR populations on their production fields.

Herbicide Program and Row Spacing Effect on PPO-Resistant Palmer Amaranth and Waterhemp. Drake Copeland*[1], Nick Hustedde[2], Matthew Wiggins[3]; [1]FMC Corporation, Dayton, OH, [2]FMC Corporation, Celestine, IN, [3]FMC Corporation, Humboldt, TN (223)

ABSTRACT

Multiple-resistant Palmer amaranth (*Amaranthus palmeri* S.Watson) and waterhemp (*Amaranthus tuberculatus* (Moq.) J.D. Sauer) infest most row-crop production acres in the U.S. Successful management of the aforementioned weeds species requires an integrated approach. The use of residual herbicides, with multiple, effective sites of action, applied at planting and during the season is very common for waterhemp and Palmer amaranth management programs. Cultural practices, such as narrowed row spacing, can also be utilized to aid in suppression waterhemp and Palmer amaranth. In 2019, research was conducted in Tennessee and Indiana to evaluate the effect of row spacing and the number of herbicide sites of action applied PRE on Palmer amaranth and waterhemp control.

In Jackson, TN, row spacing did not affect Palmer amaranth control 28 DAA. Greatest Palmer amaranth control was provided by sulfentrazone + pyroxasulfone (95%) 28 DAA. Control of Palmer amaranth was similar between treatments: sulfentrazone alone (72%), pyroxasulfone + fluthiacet-methyl (65%), and *S*-metolachlor + metribuzin (70%). The lowest control of Palmer amaranth was observed 28 DAA where *S*-metolachlor (44%) and metribuzin (24%) were applied alone.

Row spacing did not impact waterhemp control 28 DAA at Champaign, IL location. Similar waterhemp control was observed with metribuzin alone (81%), metribuzin + *S*-metolachor (93 %), pyroxasulfone + fluthiacet-methyl (81 %), and sulfentrazone + pyroxasulfone (97%) 28 DAA. Similar control was observed between metribuzin alone, pyroxasulfone + fluthiacet-methyl, and sulfentrazone alone (69%). However, waterhemp control observed with sulfentrazone alone was significantly less than metribuzin + *S*-metolachor and sulfentrazone + pyroxasulfone. The poorest waterhemp control was observed 28 DAA with *S*-metolachlor applied alone (48%).

In Year 1 of this study, row spacing did not impact Palmer amaranth or waterhemp control. This was likely due to confounding factors such as rainfall accumulation and delayed plantings experienced across the U.S. in 2019. Extensive reports of additive control of *Amaranthus* spp. has been reported where cultural weed control practices are deployed. In this study, effective control of Palmer amaranth and waterhemp was observed for PRE-treatments that comprised two, herbicide sites of action, regardless of row spacing.

Control of Multiple-Resistant Waterhemp in HT3 Soybean. Peter Sikkema*, Nader Soltani; University of Guelph, Ridgetown, ON (224)

ABSTRACT

Herbicide-resistant (HR) crops, specifically glyphosate-, glufosinate-, and dicamba- resistant (HT3) soybean will offer producers a new weed management option for the control some HR weeds in soybean. Four field experiments were conducted near Cottam and on Walpole Island, ON during 2017 and 2018 to assess the control of multiple-resistant (MR) waterhemp (herbicide groups 2, 5 and 9) in HT3 soybean treated with various herbicide programs. Pyroxasulfone/flumioxazin, flumioxazin plus metribuzin or S-metolachlor/metribuzin, applied PRE, followed by (fb) glyphosate POST controlled MR waterhemp 94, 66 and 78%, respectively in early September. Pyroxasulfone/flumioxazin, flumioxazin plus metribuzin or S-metolachlor/metribuzin, applied PRE, controlled MR waterhemp 86-97% when fb by glufosinate POST; 100% when fb glyphosate plus dicamba POST; 99-100% when fb glufosinate plus dicamba POST; and 00% when fb glyphosate plus dicamba POST and fb glufosinate POST2 in early September. Reduced MR waterhemp interference with all the herbicide programs resulted in an increase in HT3 soybean yield (up to 59%) relative to the weedy control. Results indicate that pyroxasulfone plus flumioxazin, flumioxazin plus metribuzin or S-metolachlor plus metribuzin applied PRE fb glufosinate POST, glyphosate plus dicamba POST, glufosinate plus dicamba POST, or glyphosate plus dicamba POST fb glufosinate POST2 provides similar and excellent season-long control of MR waterhemp in HT3 soybean.

The Influence of Utilizing Multiple Herbicide Sites of Action on Soil Seed Bank Dynamics. Nick Hustedde*[1], Matthew Wiggins[2], Brent Neuberger[3]; [1]FMC Corporation, Celestine, IN, [2]FMC Corporation, Humboldt, TN, [3]FMC, Des Moines, IA (225)

ABSTRACT

Utilizing diverse herbicide programs with the objective of reducing the soil seed bank is critical for long term weed management. Weed species encompassing extended emergence intervals require layered herbicide tactics for optimal control. Herbicide combinations were evaluated in Farmland, IN in 2018 and 2019 for control of PPO, ALS and glyphosate -resistant *Amaranthus tuberculatus* (common waterhemp) and their effects on soil seedbank density, resistance profile and soybean yield. Herbicide treatments included: sulfentrazone (278 g ai ha^{-1}) + cloransulam (35 g ai ha^{-1}) followed by pyroxasulfone (110 g ai ha^{-1}) + fluthiacet-methyl (3 g ai ha^{-1}) + dicamba (560 g ae ha^{-1}) + glyphosate (1262 g ae ha^{-1}), metribuzin (263 g ai ha^{-1}) followed by dicamba (560 g ae ha^{-1}) + glyphosate (1262 g ae ha^{-1}), acetochlor (1262 g ai ha^{-1}) + dicamba (560 g ae ha^{-1}) + glyphosate (1262 g ae ha^{-1}) and dicamba (560 g ae ha^{-1}) + glyphosate (1262 g ae ha^{-1}).

Herbicide efficacy 30 days after the postemergence application timing for control of common waterhemp and *Echinochloa crus-galli* (barnyardgrass) was greater than 97% with the layered residual treatment. Dicamba + glyphosate applied alone postemergence exhibited the lowest common waterhemp and barnyardgrass control. Sulfentrazone + cloransulam followed by pyroxasulfone + fluthiacet-methyl + dicamba + glyphosate resulted in 16.5% fewer specimens grown out in the fall of 2018 when compared to the baseline soil sample collected in the spring of 2018. Conversely, Dicamba + glyphosate applied alone postemergence increased the number of specimens grown out by 323.6%. Common waterhemp resistance profile was not influenced by herbicide program. Yield was increased for treatments containing sulfentrazone + cloransulam followed by pyroxasulfone + fluthiacet-methyl + dicamba + glyphosate and metribuzin followed by dicamba + glyphosate.

Control of weed species with prolonged emergence intervals is a critical challenge for weed management practitioners. This research demonstrates that employing herbicide programs encompassing multiple modes-of-action in a layered system improves weed control, reduces soil seed bank density and increases soybean yield. Sustainable weed management will require diverse strategies combining chemical, cultural and mechanical tactics with the intention of reducing the soil seed bank.

Papers: Invasive, Weeds, Rangeland, Pasture, and Vegetation Management

Comparison of Glyphosate and Imazapyr for Caucasian Bluestem Control. Walter H. Fick*; Kansas State University, Manhattan, KS (226)

ABSTRACT

Old World Bluestem (OWB) is a term use to describe both Caucasian bluestem (*Bothriochloa bladhii*) and yellow bluestem (*Bothriochloa ischaemum*). These species were primarily introduced as a forage crop but have subsequently invaded adjacent rangeland. The OWBs are less palatable than the native grasses and increase over time. Left untreated, OWB will eventually dominate a site. The current study was initiated in July 2016 and repeated in 2018 at a site in Chase County, KS. The objectives of the study were to 1) compare the efficacy of glyphosate and imazapyr applied once or two years in a row for Caucasian bluestem control, 2) determine if imazapic applied a year after glyphosate or imazapyr application provided any benefits for Caucasian bluestem control, and 3) determine any changes in botanical composition following herbicide application for Caucasian bluestem control. The site was dominated by Caucasian bluestem making up 20-38% of the botanical composition. The other vegetation consisted of a mixture of warm-season grasses including little bluestem (*Schizachyrium scoparium*) and Indiangrass (*Sorghastrum nutans*). Cool-season grasses and sedge were a minor component. The primary forbs were western ragweed (*Ambrosia psilostachya*) and heath aster (*Symphyotrichum ericoides*). On July 8, 2016 and July 12, 2018, 0.56 kg ha^{-1} imazapyr and 2.24 kg ha^{-1} glyphosate were applied using a CO_2-powered boom sprayer delivering 187 L ha^{-1} total spray solutions. Plots were about 2.0 x 7.6 m in size. About 1 year after the initial herbicide applications, the same rate of imazapyr, glyphosate, and 0.21 kg ha^{-1} imazapic were applied. Treatments were applied in a randomized block design with 4 blocks. The Daubenmire Canopy Coverage method was used to assess vegetative cover on all plots at the time of treatment and 11, and 14 months after treatment. Eleven months after treatment in 2016, Caucasian bluestem was reduced 74 and 99% by imazapyr and glyphosate, respectively. Warm-season grasses increased 24% on the imazapyr plots, but decreased 98% on glyphosate plots. Treating 2 years in a row with 0.56 kg ha^{-1} imazapyr nearly eliminated Caucasian bluestem and allowed warm-season grasses to increase and forbs to persist. Unexpectedly, treating with glyphosate 2 years in a row was not effective. Treatment with imazapic in year 2 after imazapyr and glyphosate maintained Caucasian bluestem control. In 2018 treatment with imazapyr and glyphosate provided 99 and 77% control, respectively. A dry summer reduced control by glyphosate. Treatment with imazapyr 2 years in a row eliminated Caucasian bluestem. Plots in 2018 contained less warm-season grass and didn't increase following 1 or 2 years of application. Increases in bare ground associated with herbicide application typically increased the cover by forbs.

Can I Keep My Clover? Rinskor Active – A New Herbicide Enabling Selective Broadleaf Weed Control in White Clover-Grass Pastures. David Hillger*[1], Scott Flynn[2], Chad Cummings[3], Will Hatler[4], Byron Sleugh[5]; [1]Corteva AgriScience, Thorntown, IN, [2]Corteva AgriScience, Lees Summit, MO, [3]Corteva AgriScience, Bonham, TX, [4]Corteva AgriScience, Meridian, ID, [5]Corteva AgriScience, Indianapolis, IN (227)

ABSTRACT

The high total digestible nutrient (TDN) and crude protein content of white clover can increase animal performance on pasture simply due to increased nutrient density. The higher level of magnesium in clovers decreases the potential risk of grass tetany (fatal disease associated with low levels of magnesium) in the spring months. White clover inter-seeded into toxic tall fescue pastures can reduce intake of these toxins and improve animal performance. Animals will selectively graze the clover, thereby reducing consumption of the toxic grass. Novel combinations containing the Rinskor™ Active (florpyrauxifen-benzyl) are in development to provide effective weed control in pasture and rangeland. While application of the combination of active ingredients may not be acceptable in all types of clover, its application in white clover has demonstrated promising plant safety. Several critical pasture weeds are controlled effectively with this combination. Important driver weeds such as horsenettle (*Solanum carolinense*) and dogfennel (*Eupatorium capillifolium*) are suppressed or controlled by this novel combination with the addition of MSO as an adjuvant and with attention to weed control timing which decreases a need for an additional tank mix partner.

Rinskor + Aminopyralid (Duracor): A New Herbicide for Control of Weeds in Rangeland and Pastures. David Hillger*[1], Scott Flynn[2], Chad Cummings[3], Will Hatler[4], Byron Sleugh[5]; [1]Corteva AgriScience, Thorntown, IN, [2]Corteva AgriScience, Lees Summit, MO, [3]Corteva AgriScience, Bonham, TX, [4]Corteva AgriScience, Meridian, ID, [5]Corteva AgriScience, Indianapolis, IN (228)

ABSTRACT

DuraCor™ herbicide with Rinskor™ Active (florpyrauxifen-benzyl) and aminopyralid a new Rangeland and Pasture herbicide expected to be labeled for control of annual and perennial broadleaf weeds and brush. DuraCore, composed of two active ingredients, is powered by Rinskor active. Rinskor active represents the latest member of the arylpicolinate family of chemistry, a unique and new class of synthetic auxin chemistry within the Herbicide Resistance Action Committee's Group O category. DuraCor will control a broad spectrum of more than 140 weeds including difficult to control weeds like wild carrot (*Daucas carota*), poison hemlock (*Conium maculatum*), plantains (*Plantago* spp.), and annual marshelder (*Iva annua*). Based on these efficacy data, it is anticipated that DuraCor will be a valuable tool to manage the challenging weeds found in pasture and rangeland.

Rinksor + Aminopyralid (TerraVue): A New Herbicide for Non-Crop Land Management. David Hillger*[1], Scott Flynn[2], Chad Cummings[3], Will Hatler[4], Byron Sleugh[5]; [1]Corteva AgriScience, Thorntown, IN, [2]Corteva AgriScience, Lees Summit, MO, [3]Corteva AgriScience, Bonham, TX, [4]Corteva AgriScience, Meridian, ID, [5]Corteva AgriScience, Indianapolis, IN (229)

ABSTRACT

TerraVue™ herbicide with Rinskor™ Active (florpyrauxifen-benzyl) and aminopyralid is a new Land Management herbicide anticipated to be labeled for control of annual and perennial broadleaf weeds and enhanced control of certain woody brush species. A key component of TerraVue is Rinskor™ active, a novel new active ingredient never before used rangeland and pastures and is an EPA Reduced Risk Pesticide just like aminopyralid. Rinskor active represents the latest member of the arylpicolinate family of chemistry, a unique and new class of synthetic auxin chemistry within the Herbicide Resistance Action Committee's Group O category. TerraVue will control a broad spectrum of more than 140 weeds including difficult to control weeds like wild carrot (*Daucas carota*), poison hemlock (*Conium maculatum*), plantains (*Plantago* spp.), and annual marshelder (*Iva annua*) without 2,4-D, dicamba, or metsulfuron. Based on these efficacy data, it is anticipated that TerraVue will be a valuable tool in the management of noxious, invasive and other weeds in various sites.

Papers: Weed Biology, Ecology, Management

Influence of Dicamba, Glufosinate and Glyphosate Tank-Mixtures on Weed Control as Affected by Herbicide Rates. Gabrielle de Castro Macedo*[1], Jesaelen G. Moraes[1], Vitor M. Anunciato[2], Jeffrey A. Golus[1], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]FCA/UNESP, Botucatu, Brazil (230)

ABSTRACT

XtendFlex® Soybeans are expected to be released in the market soon allowing for tank-mixtures of dicamba, glufosinate and glyphosate for postemergence (POST) weed control. The interactions among these herbicides has not been thoroughly investigated. The objective of this study was to determine if dicamba, glyphosate and glufosinate in tank-mixture combinations are synergistic, antagonistic or additive. Four greenhouse studies were conducted with a completely randomized design with four replications at the Pesticide Application Technology Laboratory in North Platte, NE using Palmer amaranth (*Amaranthus palmeri* S. Watson), green foxtail [*Setaria viridis* (L.) P. Beauv.], common lambsquarters (*Chenopodium album* L.*)* and kochia [*Bassia scoparia* (L.) A. J. Scott]. Each study was conducted in two experimental runs. Plants were treated using a three-nozzle spray chamber, with 50 cm between nozzles, at 275 kPa and 13 km ha^{-1} delivering 140 L ha^{-1}. When the weed species reached 30 to-40 cm tall they were treated with a TTI11002 nozzle 50 cm above plants. Herbicide treatments consisted of glyphosate (1262 and 631 g ae ha^{-1}), glufosinate (650 and 325 g ai ha^{-1}), or dicamba (560 and 280 g ae ha^{-1}) in all combinations among these three herbicides. Visual estimations of herbicide injury were collected at 7, 14, 21, and 28 days after treatment (DAT). At 28 DAT, plants were clipped at the soil surface and placed in a dryer (60° C) until plants reached a constant mass. Data were subjected to analysis of variance in SAS and comparisons among treatments were performed using Fisher's least significant difference procedure at $\alpha = 0.05$. Although green foxtail is not susceptible to dicamba, all treatments containing glyphosate or glufosinate, regardless of rate, provided control >90% control. For Palmer amaranth, regardless of herbicide treatment (alone or in combination) or rate (full or half), no significant differences were found. All of them provided >80% control. Overall, the combination of glyphosate and dicamba, glufosinate and dicamba, or glyphosate, glufosinate and dicamba in any rate (full or half) provided good control (>75%) for common lambsquarters and kochia. Regarding the treatments with glyphosate and glufosinate alone, they did not provide a good control and the reasons may be height by the time of the application, absence of water conditioning or rate. The variations among species suggested that additional studies are necessary to understand herbicide tank-mixture interactions.

A Kochia Population with Possible Field Resistance to Dicamba, Fluroxypr and Glyphosate. Randall Currie*[1], Patrick Geier[1], Mithila Jugulam[2], Chandrima Shyam[2], Balaji A. Pandian[2]; [1]Kansas State University, Garden City, KS, [2]Kansas State University, Manhattan, KS (231)

ABSTRACT

NO ABSTRACT SUBMITTED

Exploiting the Natural Reproduction System to Block Weed Resistance. Efrat Lidor Nili1, Ido Shwartz1, Herve Huet1, Miriam Aminia1, Micheal D. Owen2, Orly Noivirt-Brik*3; 1WeedOUT Ltd., Ness Ziona, Israel, 2Iowa State University, Ames, IA, 3WeedOUT Ltd., Ness-Ziona, Israel (232)

ABSTRACT

PAPER WITHDRAWN

Using Emergence and Phenology Models to Determine Minimum Number of Control Actions. Theresa A. Reinhardt Piskackova*, S. Chris Reberg-Horton, Robert J. Richardson, Katherine M. Jennings, Ramon G. Leon; North Carolina State University, Raleigh, NC (233)

ABSTRACT

Integrated weed management has been associated with implementing various forms of weed management but initially was concerned with exerting the minimum weed control measures when certain unacceptable loss thresholds were met. The critical period of weed control (CPWC) has been one such way to reduce weed control measures to the time where the crop yield would be most vulnerable to weed competition. Some limitations of the CPWC are the assumptions that weeds will be at a controllable size within that time, and that escapes will not contribute to the soil seed bank. These assumptions have held because specific information on weed emergence and growth is usually unavailable. Weed behavior models could provide this missing information. The objectives of this research were 1) to create models of emergence and phenology for the weed *Senna obtusifolia* (L.) Irwin and Barneby (sicklepod), 2) develop a framework for deciding the optimum timing of control actions, 3) compare how the developed models match established CPWC.

Three natural populations of sicklepod in North Carolina agricultural fields were monitored over 5 site years. Emergence, vegetative, and reproductive stages were modeled over chronological, thermal, and hydrothermal time. Using different thresholds for weed control goals, it was possible to determine the number of actions needed to reach those objectives. Some of the actions fell within the CPWC, but the expected actions did not always coincide. This approach provides a new tool to meet yield and long-term weed control objectives.

Gender-Specific Gene Expression in Dioecious *Amaranthus* Species. Yousoon Baek*, Patrick J. Tranel; University of Illinois, Urbana, IL (234)

ABSTRACT

Species of the *Amaranthus* genus are major agronomic weeds in the U.S. Specifically, waterhemp and Palmer amaranth both are dioecious (most other *Amaranthus* species are monoecious), and the presence of separate gender plants forces outcrossing, which increases genetic diversity in populations. The high genetic diversity of waterhemp and Palmer amaranth facilitates evolution of multiple resistance, resulting in formidable weed management challenges. While some weed management strategies other than herbicides, including inversion tillage and cover crops, are under investigation, a novel weed control strategy, such as a gene drive, can be pursued via molecular biology and genomic research. A gene drive method could allow for gender manipulation of dioecious *Amaranthus* species as a potential new weed control strategy. Although the target of such a drive is not yet discovered, prior research indicates that sex determination in these species is controlled by genetic factors. Through this approach, the potential goal would be to manipulate sex ratios in favor of males, theoretically resulting in local population extinction. Therefore, the research here aims to identify potential gene-drive targets through whole transcriptome sequencing to capture differentially expressed genes between female and male flowers of dioecious Amaranth species. To investigate gender-specific gene expression, total RNA was extracted from three different tissues to represent the different growth stages from each species, including shoot apical meristems for the vegetative growth, floral meristems to capture genes at the initiation of flowering, and mature flowers for the later stage of flowering. RNAseq libraries from four replicates of each tissue type in each species were prepared with Illumina's 'TruSeq Stranded mRNAseq Sample Prep kit' (Illumina), and sequenced on one NovaSeq 6000 lane. A total of 6 billion reads from a 47 libraries were generated with approximately 70 million reads from each library. The transcriptome assemblies from the RNA-seq data will be used to identify differentially expressed genes. The investigation of gender-specific gene expression will provide significant information for understanding gender determination systems of dioecy in waterhemp and Palmer amaranth.

Risk Assessment of Pollen-Mediated Gene Flow from Field Corn to Popcorn. Ethann R. Barnes*, Stevan Z. Knezevic, Nevin C. Lawrence, Amit J. Jhala; University of Nebraska-Lincoln, Lincoln, NE (235)

ABSTRACT

The popcorn industry is at great risk of genetic contamination. The popcorn industry utilizes the *gametophyte factor 1* gene (*Ga1*) as a barrier against pollen-mediated gene flow (PMGF) from dent corn. Popcorn with the *Ga1-s* allele accepts pollen from only *Ga1-s* corn, allowing for dent corn and popcorn to be planted next to each other. Dent corn germplasm is being introduced to the United States with the *ga1-m* allele which can overcome *Ga1-s* selectivity and pollinate popcorn. The risk to the popcorn industry associated with unregulated germplasm introduction has been under assessed. Experiments were conducted in 2017 and 2018 to model the frequency of PMGF from *Ga1-m* dent corn to *Ga1-s* popcorn under field conditions and to evaluate the role of wild speed and direction using a concentric donor-receptor design. PMGF to white popcorn pollen receptor was detected using a dent corn pollen donor with yellow kernel color (dominate). Kernels where harvested from cardinal and ordinal directions and distances ranging from 1 to 70 m. Information-theoretic criteria was used to select the best fit model of PMGF out of 564 double exponential decay models. The greatest PMGF (0.01615 in 2017 and 0.04113 in 2018) was detected at 1 m and declined rapidly with distance. Gene flow was detected at the maximum distances tested. Wind and metrological parameters did not improve the fit of the model; although, PMGF varied by direction. This is the first assessment of PMGF to popcorn and results are critical for preventing genetic contamination in popcorn.

Symposium: Improving the Relevance of the NCWSS to Industry

Abstracts were not requested for symposia and were submitted on a voluntary basis. The following presentations did not submit an abstract:

Challenges to Participation at the NCWSS. Andy Kendig*; ADAMA, Chesterfield, MO (236)

What is the Business Relevance of the NCWSS to 'Management' in Industry? Greg Elmore*; Bayer, Chesterfield, MO (237)

'Methods' to Attend the NCWSS. R. Joseph Wuerffel*; Syngenta, Sebastian, FL (239)

Panel Discussion: What Can the Society do to Increase its Relevance to Industry? Andy Kendig*; ADAMA, Chesterfield, MO (240)

What is the Business Relevance of the NCWSS to Individuals? Greg K. Dahl*; Winfield United, River Falls, WI (238)

ABSTRACT

The North Central Weed Science Society, NCWSS web site mentions that we are professionals interested in weed science from many perspectives. It is important for each of us to explore weed science from the different perspectives. It is also important for each of us to represent our perspectives to further the progress of weed science. Please represent the perspectives of your company, your geography, your university, field of expertise, and your knowledge and skills. It is important for you to share them always and especially at the meetings.

Involvement with the North Central Weed Science Society will improve your confidence and ability to lead both in weed science and in your industry. You have a better understanding of issues and how to deal with them. You will know who the experts are that are working in an area that becomes important to address. You will have a larger network and you will have worked in a team with others who share your goals.

It is also important for each of us to grow. We need to learn from others, in sessions and in the hallway. We need to increase our network of contacts and improve our relationships and shared interests with others. Learn to enjoy the fun and discover new friends and renew relationships with old friends. Appreciate the people that invested in you. Please invest in others that need your encouragement and friendship.

NCWSS is a volunteer organization. We have great volunteers. I encourage you to be bold. Please attend meetings and events. You will learn and may find opportunities to help and grow. There are many opportunities to volunteer to help serving on committees and teams, be a paper or poster judge, and help at the NCWSS Summer weed contest. These are great experiences for you and everyone else involved. Take time to visit with other NCWSS members. Sign up for the NCWSS social media apps and use them. We would love to see what you have to share! Whatever you contribute to NCWSS and its members will be rewarded abundantly. Thank you for your service to the NCWSS.

Symposium: Invasive Plants

Abstracts were not requested for symposia and were submitted on a voluntary basis. The following presentations did not submit an abstract:

Seeing the Forest *and* the Trees: Regional Collaboration to Address Woody Invasives in the Great Lakes Basin and Beyond. Clair Ryan*; Midwest Invasive Plant Network, Lisle, IL (242)

Stopping the Spread: The Role of Public Gardens as Sentinels Against Invasive Plants. Theresa Culley*; Ohio Invasive Plant Council, Cincinnati, OH (243)

What do we Know About the Invasiveness of Horticultural Forms of Japanese Barberry (*Berberis thunbergii*) and Winged Burning Brush (*Euonymus alatus*)? Mark Brand*; University of Connecticut, Storrs, CT (244)

Data Collection, Sharing, and Re-Use Through the Early Detection and Distribution Mapping System. Rebekah Wallace*; University of Georgia, Tifton, GA (245)

Suppression of Reed Canary Grass (*Phalaris arundinaceae*) by Assisted Succession: a 15-Year Restoration Experiment. Steve Hovick*; The Ohio State University, Columbus, OH (246)

What Can We Learn About the Rules of Nature from Plants that Break them All? Ryan McEwan*; University of Dayton, Dayton, OH (247)

Author Index

*Presenting Author
†Paper or poster in the graduate and/or undergraduate student contest

KeyWords Index

2019 NCWSS Society Information

Gold
BASF Corporation
Bayer CropScience
Corteva Agriscience
Syngenta Crop Protection
Winfield United

Silver
FMC Corporation
Helena
Valent

Bronze
ABG Ag Services
ADAMA
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Blue River Technology
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