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WSSA 3MT Student Oral Competition – MS

Survey of Herbicide Resistance and Seed Fate of Italian Ryegrass (*Lolium perenne spp. multiflorum*) in Kentucky. Amber L. Herman*, Travis Legleiter, Catlin M. Young; University of Kentucky, Princeton, KY (1)

Herbicide resistance is not a new problem for farmers in Kentucky, although the identification of herbicide resistant weed species continues to increase. Italian ryegrass (*Lolium perenne spp. multiflorum*) is a problematic weed in Kentucky soft red winter wheat that has historically been documented as herbicide resistant in isolated locations. A greenhouse herbicide screen was conducted to further understand the level of glyphosate, pinoxaden, pinoxaden+fenoxaprop and pyroxsulam-resistance in Kentucky Lolium multiflorum populations. The preliminary screen and dose response indicate there is one *Lolium multiflorum* population resistant to glyphosate and three populations resistant to pinoxaden. Harvest weed seed control is a potential option being evaluated in Kentucky to control herbicide resistant *Lolium multiflorum* in soft red winter wheat. One specific method of harvest weed seed control is the use of cage mills to destroy *Lolium multiflorum* seed found within the fine chaff exiting the combine at harvest. This can only be an efficient and viable option of control if *Lolium multiflorum* seed is retained on the seed head up to the time of harvest and is able to enter the combines chaff flow. Seed retention and dispersal of *Lolium multiflorum* was evaluated prior to and at wheat harvest in 2020 and 2021 in Kentucky. Within one week of harvest, both the *Lolium multiflorum* seed heads and the top layer of soil debris were collected from within a m^2 area for approximately each 0.2 ha of *Lolium multiflorum* infestation in eight Kentucky wheat fields. For the preharvest and harvest samples, 11,000 of the *Lolium multiflorum* seeds remained on the seed head up to wheat harvest and 85% of the seeds retained did enter the combine which makes mechanical harvest weed seed control a potential viable option of for *Lolium multiflorum* control in Kentucky wheat.

Vegetation-free Strip Width Optimization for a White Clover (*Trifolium repens*) Living Mulch in Cotton. Sambit Shome*, Nandita Gaur, Matthew Levi, Nicholas T. Basinger; University of Georgia, Athens, GA (2)

Georgia is the second-largest producer of cotton in the Southern United States after Texas. Weed infestations in cotton fields have increased over the past decade to a point where they interfere with the economic threshold and cause irreversible economic damage in cotton production. To counteract weed infestations, cover crops are used. Cover crops have a smothering effect, improve soil health properties, attract beneficial insects, and help with pollination. Cover crops when sown within and in between crops is known as living mulch. White clover (Trifolium repens L.) a perennial living mulch is used in the study with the objective to optimize the living mulch vegetation-free strip width (VFSW) in cotton. The study was conducted at two locations: J. Phil Campbell Research and Education Center (JPCREC) in Watkinsville, Georgia, and the Southeast GA Research Center (SEGREC) in Midville, Georgia. The experiment used a randomized block design, with a factorial arrangement of treatments. The first factor being the VFSW (0, 0.15, 0.30, 0.60, and 0.90 m) and the second factor being cotton seed rate (2 or 4 seeds 0.30 m-1 row) resulting in 10 treatments. Cotton was evaluated for cotton skips four-weeks after planting to determine the effect of living mulch on cotton stand establishment. Data on plant growth (height, phenology, node number) was collected biweekly. Finally, before harvest 10 plants per plot were selected randomly to evaluate cotton yield parameters (boll plant-1, lint boll-1, seed cotton yield, and lint yield). Cotton stands were impacted by the 0 m VFSW regardless of planting density. Phenological differences were also noted, as 0.90 m cotton tended to mature earlier, and 0.15 m and 0.30 m cotton mature later at the JPC which did not occur at SEGREC. Analysis from the 3-parameter Gompertz model showed that the optimal VFSW for JPC was 0.30 m while 0.90 m (bare ground) was the only acceptable for Midville to maximize yield. Seeding rate did not impact yield at either location. Hence 2 seeds 0.3 m-1 will be more advantageous for growers. The yields at Midville, GA were higher than JPC, GA. Except for the 0 m VFSW, stand establishment was within the planted range for all VFSW at both the sites.

Jack O'Lantern Pumpkin Tolerance to Fomesafen Applied Preemergence. Jeanine Arana*, Stephen L. Meyers; Purdue University, West Lafayette, IN (3)

Fomesafen is registered for PRE use in cucurbits in some Midwestern states but not Indiana. A 24C special local needs label can be requested to make this herbicide available for Indiana farmers. Crop safety data must be documented in-state and submitted for approval. We developed a research program to determine the tolerance of two pumpkin cultivars to fomesafen applied PRE. We performed three trials between 2020 (Vincennes, IN) and 2021 (Vincennes and Wanatah, IN). Experimental units consisted of three 4.9 m long bare ground raised-bed rows. In each row, we hand-seeded four pumpkins. The experiment was a randomized complete block design with four replication and a split-plot arrangement in which the main plot was the herbicide rate, and the subplot was the pumpkin cultivar. Fomesafen rates were 0, 280, 560, 840, and 1220 g ai $ha^{-1,}$ and cultivars were 'Bayhorse Gold' and 'Carbonado Gold'. The explanatory variables were herbicide rate, pumpkin cultivar, and site-year. The response variables were emergence as a percent of the control at 2 weeks after treatment (WAT), visible crop injury at 4 WAT on a scale of 0 (no injury) to 100% (crop death), and yield (total marketable fruit weight) as a percent of the control. Data were subjected to ANOVA and then to linear and non-linear regression analysis. Predicted emergence was reduced 19 to 70% as the fomesafen rate increased from 280 to 1120 g ha^{-1} at Vincennes-2020, but only reduced 11 to 33% at both locations in 2021. We attributed the significant emergence reduction at Vincennes-2020 to the herbicide moving into the crop's rooting zone due to excessive rainfall. Cumulative rainfall during 2 WAT in 2020 was 120 mm, but in 2021 it rained only 44 mm at Vincennes and 17 mm at Wanatah. Fomesafen is highly mobile under water-saturated soil conditions, especially in soils with low organic matter content, high pH, and a high proportion of sand content. Visual injury at 4 WAT included bleaching, chlorosis, and stunting, but injury was transient. Predicted marketable yield decreased 15 to 74% as the rate increased from 280 to 1120 g ha^{-1} at Vincennes-2020. However, at the labeled rate of 280 g ha^{-1}, the 15% yield reduction was not significantly different from the non-treated check. At Wanatah in 2021, the highest rate of 1120 g ha^{-1} reduced yield by 39%. Yield loss was attributed to the reduced plant stand. Overall, our data suggest that fomesafen can be broadcast-applied at 280 g ha^{-1} to bare ground within one day after seeding pumpkin, but there is a risk of increased crop injury with increasing rainfall.

Role of Glyphosate Retention, Absorption, and Translocation on the Tolerance of Two Horseweed (*Erigeron canadensis* L.) Growth Types. Justine L. Fisher*, John A. Schramski, Christy L. Sprague, Eric L. Patterson; Michigan State University, East Lansing, MI (5)

Phenotypic differences, "rosette" and "upright/bolted" growth types, of newly emerged horseweed (*Conyza canadensis*L.) have been observed co-occurring in Michigan fields. Previous research found that "upright" plants from two glyphosate-resistant populations were 4- and 3-fold less sensitive to glyphosate than their rosette siblings. However, differences in sensitivity between the two growth types in the susceptible population were not observed. Further experiments were conducted to investigate whether differences in glyphosate sensitivity between rosette and upright growth types in a resistant and a susceptible population were due to glyphosate retention, absorption, or translocation. Glyphosate interception and retention on horseweed's leaf surface was examined by applying 1.27 kg ae ha^{-1} of glyphosate with Chicago Sky Blue dye (2.5 g L^{-1}) to 4-wk old resistant and susceptible rosette (2-cm tall and 9-cm wide) and upright (6-cm tall and 10-cm wide) horseweed biotypes. Immediately after application, plants were rinsed with 15 ml of water and 0.25% v v^{-1} of non-ionic surfactant and shaken for 30 sec. Absorbance of the rinsate was measured with a spectrophotometer at 625 nm. Horseweed plants were harvested and leaf area and biomass were determined. A separate experiment was conducted using ^{14}C glyphosate to measure glyphosate absorption and translocation. Horseweed plants were harvested 0, 12, 24, 72, and 168 h after treatment (HAT) and ^{14}C glyphosate was washed off the surface of the treated leaf with 4 ml methanol-water (1:9 ratio). The remainder of the plant was divided into above the treated leaf, below the treated leaf, and roots. All plant sections were combusted in an oxidizer and released radioactivity was quantified by liquid scintillation spectrometry. All experiments were setup as a randomized complete block design with five replications and were repeated in time. The total amount of glyphosate intercepted and retained on horseweed's leaf surface was similar for both growth types; however, on a per weight and area basis the rosette growth type retained 27% and 22% more glyphosate, respectively. Additionally, glyphosate absorption was not different between the rosette and upright growth types or between the resistant and susceptible horseweed biotypes across all harvest times. The estimated time to reach 50% glyphosate absorption for each biotype was 10-13 HAT and total glyphosate absorption ranged between 85-90% 168 HAT for each population and growth type. The amount of ^{14}C-glyphosate translocated from the treated leaf to other plant parts in the upright and rosette growth types was 11% and 18%, and 7% and 9% for the susceptible and resistant populations, respectively. At 168 HAT, there was no difference in translocation between the two growth types within each biotype; however, ^{14}C-glyphosate translocation was 10-12% higher in the susceptible rosette compared with the upright and rosette growth types from the resistant biotype. These results suggest that differences in glyphosate sensitivity among the rosette and upright growth types in the resistant population and between the resistant and susceptible populations were not due to differences in glyphosate absorption or translocation. However, the upright growth type may be more tolerant to glyphosate due to reduced interception and retention of glyphosate on a per weight and area basis, resulting in a diluted concentration of glyphosate in the upright growth type. Future research should examine gene expression of glyphosate transporter genes in each growth type.

A Bioassay to Determine *Poa annua* Responses to Indaziflam. Benjamin D. Pritchard*[1], Jose J. Vargas[1], Bruce Spesard[2], James Brosnan[3]; [1]University of Tennessee, Knoxville, TN, [2]Bayer Crop Science, Cary, NC, [3]Univeristy of Tennessee, Knoxville, TN (6)

Herbicide resistance within *Poa annua* is widespread in managed turfgrass systems. In 2020, a *P. annua* collection from a golf course in the southeastern United States was reported to be resistant to indaziflam as well as six other mode-of-action groups. Considering *P. annua* is the most troublesome weed in turfgrass, a bioassay to screen other collections with putative indaziflam resistance is needed. A dose response experiment was conducted with ten concentrations of indaziflam (0, 250, 500, 750, 1000, 1250, 1500, 2000, 4500, and 9000 pM) in Gelrite® culture during 2021. An herbicide-susceptible (S1) collection of *P. annua*, a resistant standard (Site 3A), and a collection with putative-resistance to indaziflam (Site 18) were included in this experiment. Petri dishes were filled with 80 mL of Gelrite® (3.75 g L^{-1}) containing technical grade (= 98%) indaziflam (Sigma-Aldrich, St. Louis, MO) and rifampicin (1000 ppm). Each plate was sealed with parafilm after placing 15 seeds of a single collection on the Gelrite® surface. During the experiment, all plates were placed at a 75° angle to facilitate gravitropic root growth and stored in a growth chamber set to a constant air temperature of 16 °C. Each indaziflam concentration was replicated five times per *P. annua* collection. At 14 days after seeding (DAS), the length of root tissue (mm) protruding from each seed was recorded with digital calipers. Root length data from each *P. annua* collection (N = 75) were expressed as a percentage of the non-treated (0 pM indaziflam) and subjected to non-linear regression analysis to calculate indaziflam concentrations required to reduce root growth by 75% (EC_{75}). Statistically significant differences were detected among *P. annua* collections with the EC_{75} for the herbicide-susceptible collection measuring 740 pM [95% confidence interval (CI) = 663 to 829 pM] compared to 2685 pM (CI = 2137 to 3559 pM) for Site 3A and 4819 pM (CI = 3413 to 7459) for Site 18. This work will be repeated in 2022 to further validate a discriminatory dose to screen *P. annua* responses to indaziflam in Gelrite® culture.

Herbicide Program Evaluation for Control of Knotroot Foxtail (*Setaria parviflora*) in Bermudagrass (*Cynodon dactylon*) Pastures. Logan M. Dyer*[1], Nicholas T. Basinger[1], Patrick McCullough[2], Gerald M. Henry[1]; [1]University of Georgia, Athens, GA, [2]University of Georgia, Griffin, GA (7)

Knotroot foxtail (Setaria parviflora Poir. Kerguélen) is both, the only Setaria species that is perennial and native United States (US). Knotroot foxtail is becoming increasingly problematic in pastures and hayfields across the Southeastern US and closely resembles yellow foxtail (Setaria pumila Poir. Roem. & Schult.). Both knotroot and yellow foxtail have similar above ground identifiable features that can create scouting confusion for growers. Current PRE-herbicide programs can minimize the impact of annual Setaria spp., but an herbicide program for control of knotroot foxtail in pastures has not been established. Studies were established in established bermudagrass (Cynodon dactylon L. Pers.) pasture at two locations, one in Clarke County Georgia and one in Oconee County Georgia in 2020 and 2021. Treatments were either applied in the fall, spring, or combinations of fall and spring applications. Fall applications included glyphosate (352.08 g a.i. ha-1and 701.58 g a.i. ha-1), hexazinone (1,348.2 g a.i. ha-1), nicosulfuron (59.03 g a.i. ha-1) metsulfuron-methyl (15.76 g a.i. ha-1), and an untreated check. Spring applications included indaziflam (67.18 g a.i. ha-1), pendimethalin (4,462.27 g a.i. ha-1), and an untreated check. Three harvests per season were conducted to determine bermudagrass yield and weed biomass for each species present, including knotroot foxtail. Data was analyzed by Fall and Spring applications. Treatments containing indaziflam increased knotroot foxtail biomass at harvest 1 compared to untreated check and at harvest 2 compared to pendimethalin. However, applications of pendimethalin and indaziflam both increased yield in bermudagrass in each harvest with a season increase in yield by 223.5% using indaziflam and 209.2% with pendimethalin compared to no herbicide application. Fall applied hexazinone increased the biomass of knotroot foxtail compared to nicosulfuron. Fall applied nicosulfuron increased bermudagrass yield compared to the low rate of glyphosate in yearly totals. Producers should be applying a spring treatment of either pendimethalin or indaziflam to increase their bermudagrass stand. A good stand of bermudagrass is a good defense against weed biomass. More research to examine the efficacy of indaziflam on establish perennialized knotroot foxtail and knotroot foxtail seed and other Integrated Weed Management methods for control of this species in pastures and hayfields.

Impact of Cereal Rye on Soil Nutrient Dynamics with Implications for Weed Suppression.
Gustavo Camargo Silva*, Muthukumar V. Bagavathiannan; Texas A&M University, College Station, TX (8)

Cereal rye is an important cover crop species in the United States and is known to provide a multitude of benefits such as reducing soil erosion, increasing soil organic matter, reducing nitrate leaching, and suppressing weeds. Weed suppression by cereal rye can be attributed to several mechanisms, one of them being depletion of soil nutrients in the weed rooting zone. However, knowledge is lacking on the influence of cereal rye on soil nutrient status and subsequent impact on weed infestation. The objective of this study was to determine the importance of soil nutrient uptake in the weed suppression properties of cereal rye cover crop. The study was conducted at the Texas A&M Research Farm near College Station, TX during 2020-21. Cereal rye was planted at four seeding rates (0, 20, 40, and 80 kg ha^{-1}) and terminated at three timings (6, 4 and 2 weeks before planting cotton), totaling 12 treatments, which were arranged in a split-plot design with 4 replications. Soil tests were conducted in each plot before cereal rye planting to determine initial soil nutrient levels (N, P, K, S), which was then repeated immediately after cereal rye termination. The difference between the final and the initial nutrient levels indicated how the cover crop altered the nutrient environment in the soil. Cereal rye biomass production was also quantified at termination, which was carried out using glyphosate (870 g ae ha^{-1}). Cotton was planted (April 20) into the cereal rye residues with a no-till drill. Weed density and emergence pattern were assessed in the early summer. Preliminary results show that higher seeding rates significantly reduced residual nitrogen (15 ppm reduction with 5.5 t ha^{-1} biomass), and that biomass production was positively correlated ($r = 0.45$) with N uptake. Conversely, available phosphorus levels increased, especially with later termination timings (28 ppm increase with 5.5 t ha^{-1} biomass). Cereal rye biomass production did not influence soil potassium or sulfur levels. Considering that N limitations reduce weed growth, depletion of soil N can be an important mechanism of weed suppression by cereal rye. Additional investigations are ongoing to validate the response.

Utilizing Hyperspectral Imaging for Differentiation of Herbicide-Resistant Waterhemp (*Amaranthus tuberculatus*) in Midwestern Soybean Production Fields. Austin H. Schleich*[1], Prashant Jha[1], Joseph Shaw[2], Bryan Scherrer[2], John Sheppard[2], Ramawatar Yadav[1], Alexis L. Meadows[1], Avery J. Bennett[1], Ryan Hamberg[1], Edward S. Dearden[1]; [1]Iowa State University, Ames, IA, [2]Montana State University, Bozeman, MT (9)

The rapid evolution of herbicide resistance in weed species is creating management issues for sustainable crop production worldwide. Multiple herbicide-resistant (HR) waterhemp [*Amaranthus tuberculatus* (Moq.) J.D Sauer] populations have evolved, complicating management in corn and soybean fields in the Midwest. A herbicide dose-response screening has been utilized to detect HR in weed species; however, this process can be very time consuming, taking weeks or months. By utilizing hyperspectral imaging, HR weed biotypes can be detected (real-time) in a more efficient and timely manner, even prior to the herbicide application. In 2021, experiments were conducted to investigate the utilization of hyperspectral imaging for early detection of HR waterhemp biotypes in soybean production fields near Ames, IA. The objectives of this research were to: (1) differentiate waterhemp plants from other weed species present in soybean and (2) within those waterhemp plants, identify biotypes resistant to glyphosate vs. susceptible. Hyperspectral imaging was performed using ground- and UAV-based platforms. Populations of soybean, waterhemp, velvetleaf (*Abutilon theophrasti*), redroot pigweed (*Amaranthus retroflexus*), and common lambsquarters (*Chenopodium album*) were grown in the Iowa State University Agronomy greenhouse in Ames, IA during the spring of 2021 to develop calibration images. Two different waterhemp biotypes (glyphosate-resistant or susceptible) were also grown. When plants reached a height of 10 cm, imaging was conducted using a Pika L Hyperspectral Imager under artificial lighting. Field experiments were conducted in June of 2021 in multiple soybean fields with known glyphosate-resistant waterhemp infestations near Ames, IA. The Pika L Imager was mounted onto a DJI M600Pro drone. Glyphosate-resistant or susceptible plants were further confirmed by spraying plants (8-10 cm tall) with 1,740 g ae ha^{-1} of glyphosate in the field after the hyperspectral measurements. Spectral data were extracted from the Pika L imager using a Resonon software *Spectronon Pro* to develop classification images using a neural network (machine learning algorithm). A PCA plus logistic regression code was used in *Python* to analyze the spectral data. Waterhemp was differentiated from other dicot weed species with 81% accuracy. The glyphosate-resistant biotype in soybean fields was classified with 83% accuracy. These results indicate that hyperspectral imaging and neural networks hold promise for early detection of glyphosate-resistant weed biotypes in soybean production fields. Further evaluations by utilizing Normalized Difference Vegetation Index (NDVI) filters and improved training data, will aid in achieving classification accuracies >95%. In conclusion, this technology can be used to develop drone-based weed maps for timely implementation of site-specific integrated weed management (IWM) programs for managing HR weeds in crop production fields.

Redekop® Seed Destructor: an IWM Tool to Manage Herbicide-Resistant Waterhemp (*Amaranthus tuberculatus)* in Soybean. Alexis L. Meadows*, Prashant Jha, Ramawatar Yadav, Avery J. Bennett, Ryan Hamberg, Austin H. Schleich, Edward S. Dearden; Iowa State University, Ames, IA (11)

Increasing cases of herbicide-resistant (HR) waterhemp (*Amaranthus tuberculatus* [Moq.] J.D. Sauer) in the Midwestern US has created an urgent need to develop integrated weed management (IWM) strategies. Mechanical destruction of weed seeds collected by the combine (a novel method of harvest weed seed control, HWSC) can be used to reduce HR weed seed inputs at soybean harvest. Field experiments were conducted in 2020 and 2021 to evaluate the efficacy of the Redekop™ Seed Destructor in killing waterhemp seeds that enter the combine at the time of soybean harvest. A randomized complete plot design was used with four replications. Treatments included Seed Destructor turned on vs. turned off. Data on waterhemp percent seed retention, combine header loss, physical seed destruction, viability and germination were collected. Percent waterhemp seed retention was quantified by covering female waterhemp plants in pollination bags (two plants per plot) at the initiation of seed set. Seed shattering by the combine head was assessed by placing plastic trays (0.7 m wide by 1.2 m long) beneath the female plants during the combine head pass. To determine the efficacy of the Seed Destructor, eight plastic trays (0.7 m wide by 1.2 m long) were placed behind the combine to collect the threshed chaff material containing weed seeds in each plot. Percent seed destruction (physical damage) was visually assessed under a digital microscope. The efficacy of the Seed Destructor on waterhemp seed germination was evaluated by incubating seeds placed on 10-cm diameter Petri dishes (moistened with 5 ml distilled water) at 32 C/14 h and 22 C/10 h for 4 weeks. Any non-germinated seed was tested for viability using a crush test. Waterhemp seeds retained on the plants at the time of soybean harvest averaged 78% and 49% in 2020 and 2021, respectively. The combine head shattered 33% and 14% of waterhemp seeds retained on the plant at soybean harvest in 2020 and 2021, respectively. Averaged over years, the Seed Destructor mechanically destroyed 92% of waterhemp seeds that entered the combine at soybean harvest. Six percent of seeds had moderate physical damage, 22% had severe damage, and 64% were fully pulverized. Viability of moderately damaged seeds was reduced by 74% and none of the severely damaged or fully pulverized seeds were viable. In conclusion, the seed destructor would be an effective HWSC technology to manage herbicide-resistant waterhemp seed banks in soybean-based cropping systems.

The Effect of Tillage and Cover Crops on Weed Dynamics in Organic Cotton. McKenzie J. Barth*, Muthukumar V. Bagavathiannan; Texas A&M University, College Station, TX (12)

Organic production can offer farmers higher crop prices and the number of acres in certified organic production has been rising for decades. In the U.S., organic fiber is the largest and fastest growing non-food organic industry. This study was conducted to optimize organic cotton production and to determine practices that will have the greatest positive impact on yield and weed pressure. Four cover crop regimes and two tillage regimes were implemented on the Texas A&M University research farm in Burleson County, Texas. Cover crops included oats, Austrian winter pea, purpletop turnip, and a mixture of the three. Tillage regimes included conventional tillage with cultivations throughout the growing season and strip tillage with planting into a small tillage area and no tillage after planting. It was determined that conventional tillage had significantly less weed pressure and higher yields than strip tillage, with variations within cover crop species. Strip till plots were effectively lost to weed pressure for the most part, with marginal differences between cover crop species and their effect on weed pressure. Strip till practices in organic cotton were determined to be extremely difficult to manage without the use of further organic tools, while conventional tillage shows promise for organic production with the added use of cover crops.

True Cheat (*Bromus secalinus*) in Oklahoma Winter Wheat: Integrated Management of ALS Susceptible Populations. Hannah C. Lindell*[1], Misha R. Manuchehri[1], Emi Kimura[2], Todd A. Baughman[3], Lane S. Newlin[1], Caitlyn Carnahan[1]; [1]Oklahoma State University, Stillwater, OK, [2]Texas A&M University, Vernon, TX, [3]Oklahoma State University, Ardmore, OK (13)

True cheat (*Bromus secalinus*) is a difficult-to-control winter annual *Bromus* species of the southern Great Plains. In past years, true cheat has been documented to infest approximately 1.4 million hectares of harvested Oklahoma winter wheat. Biotypes cross-resistant to acetolactate synthase inhibiting herbicides have left growers with minimal management options in conventional and herbicide tolerant systems. Field trials conducted at Lahoma, Oklahoma in 2019-20 and 2020-21 evaluated integrated true cheat management using a combination of three management strategies: planting date (optimal, mid-, and late), cultivar selection (one high- and one low-competitive wheat cultivar), and two common herbicides (sulfosulfuron at 35.2 g ai ha^{-1} and pyroxsulam at 18.4 g ai ha^{-1}). In 2019-20, eight to nine weeks after treatment, visual control increased 11% at mid-planting compared to the optimal and increased 14% at late planting compared to the mid-planting. In 2020-21, similar visual control (~99%) was recorded for mid- and late plantings with 23% greater control than the optimal timing. True cheat biomass during the 2019-20 growing season had no response to planting date, cultivar, or herbicide treatment. During 2020-21, biomass was low (= 0.2 g m^{-2}) and 98% less following an application of pyroxsulam or sulfosulfuron compared to nontreated controls. Winter wheat grain at the optimal planting was greatest compared to mid- and late plantings for both growing seasons. In 2019-20, a delay in planting from the optimal to mid- or late timings decreased grain yield up to 21%. In 2020-21, a planting date by herbicide interaction occurred. Delaying planting reduced grain yield, but an application of pyroxsulam or sulfosulfuron increased yield at the optimal planting, resulting in the greatest yields (~6,057 kg ha^{-1}). Pyroxsulam or sulfosulfuron provided a reduction in true cheat biomass in 2020-21 but a delay in planting by two to six weeks after the optimal sowing window decreased overall grain yield.

CoAXium Wheat Varietal Tolerance to Quizalofop in the Southern Great Plains. Caitlyn Carnahan*[1], Misha R. Manuchehri[1], Brett Carver[1], Vipan Kumar[2], Hannah C. Lindell[1], Lane Scott Newlin[1], Justin T. Childers[3]; [1]Oklahoma State University, Stillwater, OK, [2]Kansas State University, Hays, KS, [3]Oklahoma State University, Marlow, OK (14)

CoAXium Wheat Production Systems offers postemergence control of many annual grass weeds. However, in the state of Oklahoma, crop tolerance concerns have been raised by agricultural stakeholders. To evaluate the response of winter wheat varieties that contain the AXigen trait (tolerance to quizalofop-P-ethyl), a study was conducted at Perkins and Tipton, Oklahoma and Hays, Kansas during the 2020-21 and 2021-22 growing seasons. Varieties included AP18, Crescent, Fusion, Helix, and Photon. Two herbicide treatments, 1X rate (92 g a.i. ha^{-1} of quizalofop-P-ethyl plus MSO at 1% vol/vol) and 2X rate (185 g a.i. ha^{-1} of quizalofop-P-ethyl plus MSO at 2% vol/vol) were applied at three timings: fall (three to five-leaf wheat), early spring (first hollow stem), and late spring (second node detectable). The 2X rate was only applied in the 2021-22 season. For the 2020-2021 growing season at peak visual injury, AP18 exhibited the highest level of damage of 17%, 22%, and 51% at Hays, Perkins, and Tipton, respectively. A similar trend followed for the fall application of the 2021-2022 growing season, with AP18 exhibiting the highest damage (72%) at Perkins across both rates. At Hays, a variety by herbicide rate effect was observed when evaluating percent visual injury. The 2X rate applied to Crescent and Photon resulted in ~80% injury while varieties Fusion and Helix were only injured ~41%. At Tipton, a herbicide rate effect was observed where across all varieties, the 2X rate resulted in an average of 16% more injury than the 1X rate. When evaluating grain yield for the 2020-2021 growing season, a herbicide application timing effect was present at all locations. At Perkins, the early spring timing reduced yield up to 9% compared to the fall, late spring, and nontreated control. A similar trend was observed at Tipton where there was a 9% reduction in yield for the early spring timing compared to the fall. Lastly, at Hays, the late spring application reduced yield 16%, 7%, and 11% compared to nontreated, fall, and early spring, respectively.

Investigating Potential Fitness Costs of Clopyralid Resistance in Ambrosia Artemisiifolia (Common Ragweed). Nash D. Hart*[1], Erin E. Burns[2]; [1]Michigan State University, Durand, MI, [2]Michigan State University, East Lansing, MI (15)

Herbicide resistance is an evolved defense mechanism that can have consequences on the fitness of a resistant biotype as a result of diverting resources from growth and reproduction to defense which may reduce success. Furthermore, resource-based allocation theory implies that the cost of evolved herbicide resistance may present a tradeoff for other stresses within the environment that the plant inhabits. Given this, the objective of this study was to evaluate potential fitness costs associated with clopyralid resistance in common ragweed (*Ambrosia artemiisifolia*) in a greenhouse study. The study followed a completely randomized block design with four replications. Factorial combinations consisted of biotype (clopyralid resistant or susceptible), nitrogen level (low-0 kg N/ha, medium-112 kg N/ha, or high-224 kg N/ha), non-lethal herbicide dose presence or absence (0 kg a.i./ha or 0.105 kg a.i./ha, and precipitation (ambient-100% field capacity or reduced-50% field capacity). The following measurements were taken every three weeks for the duration of the experiment: photosynthetic output (quantum yield of photosystem II (Phi2), quantum yield of non-photochemical quenching (PhiNPQ), quantum yield of other unregulated losses (PhiNO), and relative chlorophyll (RC)), plant height, and leaf number. Plant maturation rates were assessed by measuring days after emergence to the appearance of buds and production of pollen. Finally, plant biomass was weighed after plant senescence, and seeds were collected. Data were analyzed using linear mixed effect models in R and means were separated using Tukey's HSD. The rate of plant maturity was impacted by a three-way interaction between biotype, nitrogen level, and non-lethal herbicide dose ($p=0.005$). The resistant biotype under high nitrogen and non-lethal herbicide buds emerged 22.3 days earlier than the susceptible biotype under medium nitrogen and non-lethal herbicide dose averaged across precipitation levels. Plant height measured three weeks after emergence was modified by a three-way interaction between biotype, nitrogen level, and non-lethal herbicide dose ($p=0.02$). The resistant biotype under high nitrogen and no non-lethal herbicide dose was 40% shorter than the susceptible biotype under low nitrogen and non-lethal herbicide dose averaged across precipitation levels. Biomass was altered by a two-way interaction between biotype and herbicide ($p=0.017$). The susceptible biotype with non-lethal herbicide application had a 22% decrease in plant biomass compared to the susceptible biotype without non-lethal herbicide application, however, there was no difference between resistant and susceptible biotypes regardless of herbicide application, averaged across precipitation and nitrogen levels. When Phi2 measured 9 weeks after emergence, was modified by a two-way interaction between biotype and precipitation ($p=0.014$). The resistant biotype under ambient precipitation had lower levels of Phi2 than the susceptible biotype under ambient and reduced precipitation averaged across nitrogen and herbicide treatments. When RC was measured in the reproductive growth stage there was a three-way interaction between biotype, non-lethal herbicide dose, and precipitation ($p=0.0025$). The resistant biotype under ambient precipitation and non-lethal herbicide RC was 75% lower compared to the susceptible biotype under reduced precipitation and no non-lethal herbicide dose averaged across nitrogen levels. In conclusion, the resistant biotype is potentially less competitive than the susceptible biotype due to shorter height and reduced photosynthetic efficiency during vegetative growth stages.

Field Evaluations of Early Post Emergence Herbicide Tolerance on Texas Native Grasses.
Wyatt J. Stutzman*, Zachary S. Howard, Matthew Matocha, Scott A. Nolte; Texas A&M University, College Station, TX (16)

Pasture renovation and re-establishment to native forage species is a desirable practice in Texas (Godefroid et al, 2010); however, competition with weeds makes establishing these forages challenging due to the lack of herbicide options (Randall, 2017). Therefore, eight species of common Texas native pasture grasses were evaluated for tolerance of three herbicides treated at a 1x rate. The trial was a conducted with each species separated into a randomized complete block design. The trial consisted of four replications, three treatments and a non-treated check in each replication, for each species. The eight species evaluated were Blue grama (*Bouteloua gracilis*), Sideoats grama (*Bouteloua curtipendula*), Hooded windmillgrass (*Chloris cucullata*), Sand lovegrass (*Eragrostis trichodes*), Green Sprangletop (*Leptochloa dubia*), Buffalo grass (*Bouteloua dactyloides*), Galleta grass (*Pleuraphis jamesii*), and Little bluestem (*Schizachyrium scoparium*). The treatments consisted of Beyond (imazamox) 0.045 kg a.i./ha, Duracor (florpyrauxifen-benzyl & aminopyralid) 0.008 kg a.i./ha and 0.093 kg a.i./ha respectively, and Talinor (bromoxynil & bicyclopyrone) 0.205 kg a.i./ha and 0.049 kg a.i./ha respectively. Treatments were made 7-10 days after emergence, with ratings taken weekly for the first 30 days after application and bi-weekly until 60 after application. Ratings compared overall damage to the plot, percent cover, major herbicide injury (symptoms), secondary herbicide injury (symptoms) and average height. At 60 days after application, final ratings were taken, and biomass was harvested from two feet per plot. Biomass samples were dried and weighed for comparison to the non-treated check. The treatments including Beyond and Duracor consistently showed little or no significant difference from the non-treated check. Talinor consistently caused significant difference in herbicide injury including stunting and biomass reduction. Reduced herbicide injury with Beyond and Duracor suggest that these herbicides may be viable options for controlling weeds during the early growth stages in Texas native grass pastures.

Weed Suppression by Cotton Chromosome Substitution Lines at Different Cover Crop Production Systems. Alyssa L. Miller*; Mississippi State University, Starkville, MS (18)

Weedy plant species have been and continue to be an extreme issue affecting crops, including cotton. A specific weed type that is of major nuisance to cotton (*Gossypium hirsutum*), in particular, is known as Palmer amaranth (*Amaranthus palmeri*). Plamer amaranth's unfortunate ability to form herbicide resistance has created a dire need for alternative methods that are more sustainable in controlling weed populations, besides the most common form- chemical control by way of herbicides. In the current study, 6 cotton chromosome substitution lines (CS-10, CS-34, CS-1, CS-6, UA 48, and TM1) were chosen based off data from Fuller et al. 2021 for top weed suppression alongside 4 different cover crop treatments regarding weedy populations in cotton crop. During the experiment conducted by Fuller et al. in 2021, 43 individual cotton CS lines and Palmer amaranth were analyzed using a stairstep structure method. Results were taken on mean Palmer height reduction- in which the 6 CS lines chosen for the current study showed considerably more height reduction of the weed. Along with the proven allelopathic abilities of these 6 CS lines of cotton to suppress the weedy species of Palmer amaranth, it is important to explore the effects on weed diminishment with the simultaneous use of cover crops. The cover crops Rye (*Secale cereal*), Crimson Clover (*Trifolium spp.*), Hairy Vetch (*Vicia spp.*), and Radish (*Raphanus raphanistrum*) were studied for weed suppression abilities by Werle in 2019 using a split- plot design. Data taken represented percentage of weed density for 5 different weed species (Carpetweed (*Mollugo verticillata*), Large crabgrass (*Digitaria sanguinalis*), Smallflower morningglory (*Jacquemontia tamnifolia*), Palmer amaranth (*Amaranthus* palmeri) and Yellow nutsedge (*Cyperus esculentus*). Certain cover crop combinations proved to be successful at weed density diminishment, including Rye and Vetch on Palmer amaranth. The knowledge of weed suppressive abilities of specific cover crops along with the use of new allelopathic cotton CS varieties could be crucial to the successful battle against herbicide- resistant weeds growing among cash crops and hindering these crop's ability to thrive. Although much is factually known about the topic of cover crops, more research and discovery need to be accomplished with more detail and among different treatments in order to realize the full potential of their use in agricultural environments.

Anaerobic Soil Disinfestation: Microbial Driven Weed Management Technique. Gursewak Singh*, Matthew A. Cutulle; Clemson University, Charleston, SC (19)

Yellow nutsedge (*Cyperus esculentus* L. CYPES) is the most problematic weed in plasticulture vegetable production due to its ability to puncture plastic mulches. Weed control options are limited for vegetable crops due to absence of effective herbicide chemistries. The limited current herbicide options risk carryover and damage to subsequent crops. Alternative non-chemical weed control tactics are needed. Anaerobic soil disinfestation (ASD) is biologically based method, which has the potential to fit into current weed management. ASD is a carbon source-driven soil microbial process that creates antagonistic conditions, such as microbial community shifts, production of volatile organic compounds, reduced soil pH and higher anaerobic conditions that can inactivate certain weed seeds. Two experiments were conducted jointly at Clemson University Coastal Research and Education Center and USDA ARS vegetable laboratory, Charleston, South Carolina to utilize ASD for controlling weeds. The objective of first study was to evaluate the potential of various mix carbon amendments in ASD procedure to control weeds in a greenhouse. The mix carbon amendments included were molasses + mustard meal (MMM), molasses + chicken manure (MCM), molasses + corn gluten (MCG) and molasses + sweet potatoes (MSP). All ASD treatments effectively controlled weeds by 75–96% compared to the control. MMM was generally the most effective carbon treatment in the greenhouse study. The second study was carried out in field settings in the fall 2020 and 2021 to test MMM combinations (best ASD treatment from greenhouse study) for yellow nutsedge control in tomato (*Solanum lycopersicum* L.) and bell pepper (*Capsicum annuum)*. The treatment design consists of a factorial with four carbon sources treatments (mustard meal, molasses, mustard meal + molasses (MMM), none) by two ASD treatments (plastic sealed and unsealed). Carbon treatments were applied, then plots were sealed with a totally impermeable film (TIF) clear mulch. Holes were poked on the sides of unsealed plots. After four weeks, ASD was terminated, and plots were left undisturbed for one week to regain oxygen. Tomato (*Solanum lycopersicum* L.) and Bell pepper (*Capsicum annuum)* were transplanted. Weed counts, crop vigor, stand counts and crop yield data were collected regularly. Significantly higher anaerobic soil conditions were achieved in carbon source sealed treatments ($P<0.05$). Yellow nutsedge emergence 0, 30, 60 and 90 days after ASD were significantly influenced by carbon source ($P<0.001$), plastic mulch seal ($P<0.001$) and their interaction ($P<0.05$). Carbon source and plastic seal significantly impacted grass weed emergence ($P<0.001$). We observed slightly stunted crop plant growth or phytotoxicity in MMM sealed plots. No significant differences in marketable yield were observed between all treatments. The results suggested that ASD incorporated with mixed carbon treatments can effectively maximize weed management in plasticulture production. However, more research is needed to determine whether ASD kills weed seeds/tubers permanently or induces weed seed dormant conditions in the soil.

WSSA 3MT Student Oral Competition – PhD

Sterile Pollen Technique as a Novel Weed Management Tool. Wenzhuo Wu*, Mohsen B. Mesgaran; UC Davis, Davis, CA (21)

The overall goal is to examine the possibility of using sterile pollen to disrupt seed production in dioecious weeds in a similar way to the Insect Sterile Technique (IST). Using dioecious Palmer amaranth (Amaranthus palmeri) as a model system, I hypothesize that seed production in this weed can be reduced by pollinating with irradiated and sterile pollen. The objectives are to 1) determine optimal irradiation dose for pollen sterilization and 2) pollen storage conditions for large scale application. Male and female plants were planted and isolated in separate greenhouses when they reached the flowering stage. The fresh and mature pollen were collected and irradiated with gamma ray from Cesium-137 at dosages of 0,100, 200, 300, 400 and 500 Gy. Irradiated and untreated pollen were immediately used for two experiments: hand-pollination and pollen viability study. For hand-pollination study, each dosage had six treatments with five replications. On each female plant, six lateral inflorescences of similar size were selected, which received 1) no pollen, 2) only non-irradiated pollen, 3) only irradiated pollen, 4) non-irradiated pollen after irradiated pollen, and 5) irradiated pollen after non-irradiated pollen. The inflorescences were bagged immediately after pollination. The sixth inflorescence was not bagged to allow for 6) open pollination. Flower number and seed number were measured after harvesting. Pollen viability was assessed using 2,5-diphenyl monotetrazolium bromide (MTT) on irradiated pollen immediately after irradiation and after one week, 1 month, 3 months, 6 months and one year storage under -80, -20, 4, and 20 ºC respectively. Results showed 300 Gy is the most effective irradiation dose and -80 ºC is the optimal temperature to maintain the viability of irradiated pollen. In addition, as applying small volumes of pure pollen under real field conditions is difficult, it therefore needs to be diluted with inert materials and delivered as an easy-to-release formulation for large scale applications. Future work will be determining an ideal dry dilute at a most effective mixed ratio for large scale application and finding the optimal frequency of sterile pollen application. This method can be extended to control multiple weed species (broad-spectrum weed control), where sterile pollen from multiple weed species can be mixed and released in a single application. Furthermore, the sterile pollen technique can be particularly helpful for managing herbicide resistant weeds that have withstood in-season control and ready to produce seeds.

Growth Response of Palmer Amaranth (*Amaranthus palmeri*) to Temperature, Moisture, and Combined Stressors. Sarah E. Kezar*, Aniruddha Maity, Muthukumar V. Bagavathiannan; Texas A&M University, College Station, TX (22)

Future climatic scenarios are expected to influence the growth of weeds and their interaction with crops. Palmer amaranth (*Amaranthus palmeri*), a C_4 species, is inherently an aggressive and stress tolerant specie in the current climate, but its growth and development under temperature and moisture stress conditions is unknown. The objective of this study was to understand the impact of elevated temperature and soil moisture stressors on the growth of Palmer amaranth. A split-plot arrangement consisted of the effects of four temperature levels of 25/20°C, 30/25°C, 35/30°C, and 40/35°C (day/night) with a 14-hour photoperiod as the main-plot and four soil moisture stress levels as the sub-plot, i.e., field capacity, 75% of the field capacity, 50% of the field capacity, and 25% of the field capacity were implemented. The experiment was conducted in the controlled environment growth chambers (Conviron MTPS) located at the Norman E. Borlaug Center for Southern Crop Improvement Greenhouse Facility, Texas A&M University, College Station, TX. A Palmer amaranth population obtained near College Station, TX was established with 3 replications for each treatment, and 4 plants within each replication. Following physiological maturity, the experiment was terminated and plants were harvested. ANOVA was conducted using SAS (version 9.4), with mean separation performed using Tukey's HSD at a = 0.05. It was observed that Palmer amaranth altered its leaf archetype, thickness, surface texture, and color in response to increasing temperature and moisture stress levels. This physiological response was best illustrated with the relative amount of chlorophyll present in the leaf (SPAD-502 Meter) where higher SPAD values reflect increased chlorophyll content. At peak vegetative growth, plants in 25/20°C and 30/25°C temperature levels averaged SPAD values of 26 and 28, respectively. With increased temperature and moisture stress levels of 35/30°C and 25% field capacity, plants significantly increased chlorophyll content to 32 SPAD. Chlorophyll content values were further separated in the 40/35°C temperature level with 100% field capacity not being significantly different from non-stressed plants, but 75%, 50% and 25% field capacity levels reaching the SPAD values of 35, 40, and 42, respectively. This illustrates the ability of Palmer amaranth to adapt under increasing levels of temperature and moisture stresses. The impact of all treatment levels on photosynthetic output, such as stomatal conductance and transpiration rate, were also documented (LI-6800 Portable Photosynthesis System). Stomatal conductance values were the lowest at 25/20°C and 30/25°C temperature levels at 100% field capacity (the least stressed plants), at 0.018 mol m^2s^1 and 0.019 mol m^2s^1, respectively. The highest stomatal conductance response, across temperature levels, was with plants at 100% field capacity levels at an average of 0.02 mol m^2s^1. Transpiration rate exhibited similar trends with non-stressed plants at 100% field capacity in 25/20°C having a significantly lower rate of 0.018 mol m^2s^1. Transpiration rate thereafter increased as a gradient across temperature and moisture stress levels, with plants at 75% field capacity averaging 0.019 mol m^2s^1. At 75% and 100% field capacity, across the temperature levels, transpiration rate was the highest as 0.02 mol m^2s^1. Results reflect how Palmer amaranth, can maintain a significantly higher photosynthetic capacity under moisture and temperature stress conditions using osmotic adjustment. Across temperature levels, Palmer amaranth accumulated vegetative biomass with the highest recorded in plants at 100% field capacity ranging from 2.75-3 g $plant^{-1}$. Biomass was not severely impacted across temperature levels at 75% field capacity with 2.3-2.75 g $plant^{-1}$. However, plant biomass was significantly reduced at 50% and 25% field capacity levels with an average of 2 g $plant^{-1}$ and 1.75 g $plant^{-1}$, respectively. Results provide valuable insights into the adaptive potential of Palmer amaranth to temperature and moisture stress conditions. Findings will help improve our understanding of weed-crop interactions under future climatic scenarios.

Pollen-mediated Gene Flow from Herbicide-resistant Corn to non-GMO White Corn Under Field Conditions. Mandeep Singh*[1], John Lindquist[1], Stevan Knezevic[2], Suat Irmak[3], Vipan Kumar[4], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]Penn State University, State College, PA, [4]Kansas State University, Hays, KS (23)

Nebraska is the number one producer of non-genetically modified organism (GMO) food-grade white corn in the United States. The co-existence of non-GMO white corn with high amylase hybrid corn (Enogen) for ethanol possess a risk for the genetic identity of non-GMO white corn because of pollen-mediated gene flow (PMGF). Nebraska growers have reported economic losses as genetic contamination of non-GMO white corn from adjoining Enogen corn fields leads to losses in quality and value-added processing of end-use products such as tortillas and chips. Therefore, a field experiment was conducted in 2021 at South Central Ag Lab, University of Nebraska, Clay Center, NE to determine the frequency of gene flow from herbicide-resistant yellow corn (Enlist™ corn) to non-GMO food-grade white corn and to assess the role of wind speed and direction using concentric donor-receptor design. We collected white corn kernels from cardinal and ordinal directions from 1 to 70 m. PMGF decreased with distance with the greatest (19.5 %) frequency at 1 m. We reported 0.32 % PMGF even at the maximum distance of 70 m. Model-analysis will be conducted to evaluate the relation of wind speed and direction with PMGF. We will also conduct 5-enolpyruvylshikimate 3-phosphate synthase (EPSPS) gene amplification to confirm PMGF with a molecular marker. The result of this study reveals the risk for cross-contamination of white corn from Enogen corn.

Multi-State Trial Evaluating Peanut Response to Glyphosate + Dicamba at Low-Doses and Multiple Exposures. Chad Abbott*[1], Eric P. Prostko[1], Todd A. Baughman[2], Peter A. Dotray[3], William J. Grichar[4], Michael W. Marshall[5], David L. Jordan[6], Pratap Devkota[7], Steve Li[8]; [1]University of Georgia, Tifton, GA, [2]Oklahoma State University, Ardmore, OK, [3]Texas Tech University and Texas A&M University, Lubbock, TX, [4]Texas A&M University, Yoakum, TX, [5]Clemson University, Blackville, SC, [6]North Carolina State University, Raleigh, NC, [7]University of Florida, Jay, FL, [8]Auburn University, Auburn, AL (24)

Dicamba-tolerant crops such as cotton (*Gossypium hirsutum* L.) and soybean [*Glycine max* (L.) Merr.] have garnered a significant amount of acceptance among growers across millions of acres throughout the southeast and southwest US. This technology is pivotal in combating and managing glyphosate and ALS-resistant weeds. Due to the increased adoption of this technology, susceptible crops such as peanut (*Arachis hypogaea* L.) are at an increased risk of off-target and/or spray tank contamination events. Research has been conducted evaluating peanut response to dicamba at single application timings at various rates with significant yield losses occurring during early reproductive stages. Peanut response to glyphosate has also been evaluated with yield reductions of 12%, 24%, and 36% when treated with rates of 240, 320, and 470 g ae/ha, respectively. However, limited data on peanut response to multiple exposures of low-dose rates of glyphosate + dicamba is available. Therefore, the objective of this research was to determine the effects of low rates of glyphosate + dicamba applied at multiple timings on peanut. Eight states conducted small-plot field trials in 2019 and 2020 for a total of 15 site locations. Peanut varieties were planted based upon state preferences and 14 of the 15 locations were irrigated. Herbicide treatments were arranged in a randomized complete block design with a 2 (timing) X 3 (rate) factorial arrangement with 3 or 4 replications. Glyphosate + dicamba timings were 30 + 60 days after planting (DAP) or a 30 + 60 + 90 DAP. Glyphosate + dicamba rates were 25.2 + 11.2 ($1/50^{th}$ X) and 12.6 + 5.6 g ae/ha ($1/100^{th}$ X), respectively. A non-treated control or 0 rate was also included. Treatments were applied using standard small-plot techniques across all locations. Plot areas were maintained weed-free using a combination of herbicides and hand-weeding. Data collection varied by location, but yield was collected at all locations. Yield data were subjected to ANOVA using PROC GLIMMIX and means separated using the Tukey-Kramer HSD Method (P=0.05). The southeastern yield data were pooled across years and 5 states (AL, FL, GA, NC, SC) and southwestern yield data were pooled across years and 3 locations (OK, TX-S, TX-W). There was no rate*timing interaction in the southeast, but the main effect of rate was significant. Peanut yield was reduced by 9% at the $1/50^{th}$ X rate when averaged over all timings. Peanut yield was not significantly reduced by any rate or timing in the southwest. In summary, peanuts were more sensitive to applications of glyphosate + dicamba in the southeast in comparison to the southwest. Precautions should be taken when applying these broad-spectrum herbicides near peanut fields. However, multiple exposure events of glyphosate + dicamba at rates = $1/100^{th}$ X should not result in significant peanut yield loss.

Allelopathy: an Alternative Approach for Integrated Weed Management in Sweet Potato.
Varsha Varsha*[1], Isabel Schlegel Werle[2], Mark W. Shankle[3], Stephen L. Meyers[4], Te-Ming (Paul) Tseng[5]; [1]Mississippi State University, Starkville, MS, [2]University of Arkansas, Fayetteville, AR, [3]Mississippi State University, Pontotoc, MS, [4]Purdue University, West Lafayette, IN, [5]Mississippi State University, Mississippi State, MS (25)

Sweet potato is an essential commodity in the United States which generated $726 million in 2021. It is the 5th most important crop globally, also known as famine relief food. North Carolina and Mississippi rank numbers one and two in sweet potato acreage in the US. The major constraint in sweet potato production is weeds interference. Weed management is a concern among 87% of organic/transitional sweet potato producers. Several chemical herbicides are currently used to control these weeds, but these herbicides have several adverse effects on our environment, ecosystem, biodiversity, organism's health, including humans, and result in the development of herbicide resistance in weeds. Because of these reasons, there is a need for an alternative weed management strategy that is effective and economically sustainable. The current study investigates alternative weed management strategies, and allelopathy is one such environment-friendly and safe means of weed control. If a crop has strong allelopathic action against various weeds, it can be used as a potential source for controlling weeds with minimum dependency on herbicides. Though allelopathic studies are scarce for sweet potato, some studies have demonstrated that it has significant allelopathic properties, and different varieties exhibit different rates of weed inhibition. A better understanding of allelopathy and the production of allelochemicals will allow us to improve the weed-suppressive potential of crops. Furthermore, identifying chemicals/genes involved in weed suppression will provide insight into the mechanism(s) associated with allelopathy. Results from this study will help identify sweet potato varieties with the potential to suppress weed growth, which can be helpful for breeding cultivars designed for organic production systems.

Response of Blackberry and Citrus to Spring and Autumn Indaziflam Applications Over Time. Nicholas L. Hurdle*[1], Timothy L. Grey[1], Keith S. Rucker[2]; [1]University of Georgia, Tifton, GA, [2]Bayer Crop Science, Tifton, GA (26)

Though Georgia is known primarily for peanut, peaches, and pecans, the sandy soils are conducive for citrus and blackberry production. Interest in horticultural crop production has led to an expansion in U-pick and fresh produce markets in Georgia. Thorough and extensive weed management programs are crucial in any crop production system. The use of residual herbicides can reduce the overall chemical usage in a growing season, along with the use of other integrated weed management strategies. Indaziflam is a cellulose microfibril inhibitor that is commonly used in pasture, turf, and horticultural crop, but little information is available regarding indaziflam usage in Georgia soils. Multiple experiments were performed to investigate the growth response of blackberry and citrus to Spring and Autumn indaziflam applications in Georgia. Blackberry experiments were performed from 2012 through 2014 and in citrus between 2020 and 2022. Design of the blackberry study consisted of one location in Lanier Co., GA and treatments consisting of glufosinate alone at 1,130 g ai ha^{-1}, and in combination with indaziflam at 35, 75, or 145 g ai ha^{-1}. The citrus experiment consisted of 2 locations, with one location from 2020 through 2021, and the second from 2021 through 2022. Treatments included glyphosate at 1,337 g ae $^{ha-1}$ alone, glyphosate + indaziflam at 51g ai ha^{-1} , glufosinate at 1,314 g ai ha^{-1} + indaziflam, and glufosinate in combination with flumioxazin at 215 g ai ha^{-1}, diuron at 1,684 g ai ha^{-1}, pendimethalin at 2,316 g ai ha^{-1}, simazine at 2,246 g ai ha^{-1}, pendimethalin + simazine, and norflurazon at 1,123 g ai ha^{-1}, and a non-treated control, (10 treatments) with all herbicide treatments including UAN at 0.95 L per 378.5 L. Both experiments were designed as an RCBD with 4 replications per treatment. Growing degree day (GDD) information was collected for the blackberry experiment. Data collected included trunk or stem diameter for both experiments, and percent weed control and percent residual control compared to the non-treated controls. Data in the blackberry experiment were subjected to ANOVA using PROC MIXED with means separated by Tukey-Kramer HSD set at an alpha of 0.05 to determine treatment, GDD, and treatment by GDD interactions. Data from the citrus experiment were also subjected to ANOVA and Tukey-Kramer HSD to determine treatment differences. No treatment differences were indicated for any year with respect to the blackberry experiment. Differences were only noted for GDD's in 2012 and 2014 with an increase in GDD's resulting in a stem diameter increase. In citrus, there were no differences for trunk diameter with respect to herbicide treatments. Treatments including indaziflam provided the greatest amount of residual control for the duration of the study with 70% and 88% control in year one and two, respectively.

Mitigating the Residual Activity of Preplant Glyphosate on Broccoli and Collard Transplants. Hannah E. Wright*, Taylor M. Randell, Jenna C. Vance, A Stanley Culpepper; University of Georgia, Tifton, GA (27)

Broccoli (*Brassica oleracea* var. *italica*) and collards (*Brassica oleracea* var. *viridis*) are sensitive to many herbicides. Glyphosate is often used before planting to control emerged weeds and is not expected to harm crop growth. However, recently published research suggests that in certain soil types, the residual activity of glyphosate can cause significant injury to sensitive produce crops. Therefore, a field experiment was conducted 2 times in the fall of 2019 and 2020 near Ty Ty, GA (92% sand, 6% silt, 2% clay, 0.58% OM) to evaluate transplanted broccoli and collard response to glyphosate applied preplant. This experiment was a randomized complete block design with a three-factor factorial treatment arrangement. The first factor, glyphosate rate, consisted of 0, 2.5, or 5.1 kg ae ha^{-1} glyphosate applied preplant. The second factor consisted of tillage (roto-tiller) after herbicide application or no tillage after application. The third factor consisted of irrigation (0.6 cm) after herbicide application or no irrigation after herbicide application. Eight hours after all treatments were applied, a mechanical hole puncher created holes for broccoli and collards to be transplanted by hand. Irrigation did not influence herbicide activity but both glyphosate rate and tillage influenced crop response. Without tillage at 28 days after treatment, glyphosate at 2.5 or 5.1 kg ae ha^{-1} injured broccoli and collards 15-79% and 30-93%, respectively. Plant widths of each crop, at that same interval, noted the aforementioned rates of glyphosate caused a reduction of 12-56% and 27-71%, respectively. Broccoli yields were reduced 35% by glyphosate at 2.5 kg ae ha^{-1} and 63% when applied at 5.1 kg ae ha^{-1}; collard yields were reduced 50% and 73% with greater impact from the higher rate. When tillage was implemented after the glyphosate application and before transplanting, visual injury, plant width growth, and yield were not influenced by the herbicide. These data suggest glyphosate rate and incorporation by tillage can influence the residual activity of glyphosate when producing fresh market broccoli and collards.

Glufosinate-Resistant Palmer Amaranth: an Update on the Resistance Mechanism. Pamela Carvalho-Moore*[1], Jason K. Norsworthy[1], Fidel Gonzalez Torralva[1], Scott McElroy[2], Tom Barber[3], Thomas Butts[1]; [1]University of Arkansas, Fayetteville, AR, [2]Auburn University, Auburn, AL, [3]University of Arkansas, Lonoke, AR (28)

Palmer amaranth [*Amaranthus palmeri* (S.) Watson] is among the most problematic weeds in row crops in Arkansas. This weed has been reported resistant to nine herbicide sites of action, and the latest resistance development reported was glufosinate resistance in accessions from Arkansas. Thus far, the resistance mechanism is unknown. Understanding which mechanism causes resistance may help researchers find alternative controls and correct management approaches. The objective of this study was to investigate the mechanism for resistance to glufosinate in a Palmer amaranth accession from Arkansas, specifically focusing on quantifying chloroplastic glutamine synthetase (*GS2*) copy number and expression. Glutamine synthetase is the enzyme inhibited by glufosinate. Seedlings of one glufosinate-resistant (RR1) and two susceptible (SS1 and SS2) accessions were grown in a greenhouse at the Milo J. Shult Agricultural Research & Extension, Fayetteville, AR. Gene copy number assay was conducted with nontreated plants from the susceptible accessions, and glufosinate survivors from the resistant accession sprayed with glufosinate at 656 g ai ha^{-1}. Four biological replications were tested for each accession. Native gene expression analysis was conducted with nontreated plants from the three accessions previously mentioned, and three biological replications were tested for each accession. Each biological sample had two technical replicates for each primer pair in both assays. These assays were performed using the standard quantitative polymerase chain reaction (qPCR) methodology with two runs. *GS2* copy number and expression were calculated relative to two reference genes (single gene copy). Data obtained were subjected to analysis of variance (JMP Pro 15), and means were separated by Fisher's protected LSD (a= 0.05). Calculated against two reference genes, RR1 had a significant increase in gene copy number and expression compared to the susceptible standards. Accession RR1 had 85 and 86 *GS2* copies, while SS1 and SS2 had only 2 copies. Regarding gene expression, RR1 showed a 15- and 31-fold increase. Similar to the results obtained in the *GS2* copy number assay, the susceptible accessions showed no increase in *GS2* expression. The increase in gene amplification and overexpression of the glutamine synthetase enzyme, specifically the chloroplastic isoform, is likely the mechanism conferring resistance to glufosinate in the resistant accession investigated in this study. The overproduction of glutamine synthetase allows resistant plants to maintain the photorespiration pathway after glufosinate applications.

Comparative Emergence and Phenology of Female and Male Palmer Amaranth. Ednaldo A. Borgato*, Mithila Jugulam, Anita Dille; Kansas State University, Manhattan, KS (30)

Palmer amaranth (*Amaranthus palmeri*) is a troublesome weed in US cropping systems and integrated weed management (IWM) is critical. Incorporating knowledge about biology of weeds is key for the success of IWM. We investigated the phenology of female and male Palmer amaranth aiming to identify differences in their life cycle to incorporate as strategy to reduce seed production and improve control of this species. The experiment was performed in a greenhouse (30 C and 16 h day length) with one hundred individuals of a single population (MS-S1). Plant gender was documented upon flowering, and phenological stage, height, length of inflorescence every other day. Phenology of female and male plants was analyzed using a linear regression model based on growing degrees days (GDD) required to reach each stage. Correlation between plant height and life stage was analyzed using Pearson's test. The length of female and male inflorescence was analyzed using a Fisher's protected LSD test. Forty-four females and fifty-seven males were observed, with a 1.3 male-to-female ratio. GDD requirements for emergence was not different between females and males, and their phenology was also similar, except for reproductive phases, in which females are the only ones that develop fruits. Plant height had a correlation with phenological stage, suggesting that it could be used as parameter to decide when post-emergence applications need to be done in the field scenario. The length of the inflorescence in the main stem was not significant between female and male individuals, suggesting that both genders invest similar resources in the reproductive phases. The absence of difference in emergence and phenology of female and male Palmer amaranth indicates that gender is not a characteristic that could be incorporated in IWM approaches. Future research includes the investigation of phenology *versus* plant height and herbicide efficacy.

Output Characteristics and Weed Control Efficacy from Targeted Application Devices in Ornamental Turfgrass. John M. Peppers*, Shawn Askew; Virginia Tech, Blacksburg, VA (31)

In intensively managed ornamental turf, such as golf course putting greens, few selective herbicides are labeled and most of these still carry substantial risk of turf injury. Broadcast application of selective herbicides in these management systems are often avoided in favor of targeted weed control techniques, such as hand cutting, dabbing, or spot spraying. Targeted-application devices (TAD), such as dabbers or spot sprayers, have been utilized in the turf and ornamentals industry for many years, but have never received scientific scrutiny. Turf managers desire to use TADs with selective herbicides to reduce collateral turf damage, use more effective herbicide rates on escaped weeds, and reduce chemical cost. These TADs, however, are marketed for use only with nonselective herbicides, and contain no reference to application volume or actual herbicide rate per unit area. In order to properly examine weed control efficacy of targeted applications, the output characteristics of TADs must be characterized. The objectives of this research were to evaluate annual bluegrass control when selective herbicides are applied with a dabbing TAD and characterize the amount and consistency of application volumes from several commercially available TADs. We hypothesized that herbicide output would be highly variable between devices, but consistent within a given device. We also hypothesized that herbicide applications would effectively control annual bluegrass when applied as a targeted application.A randomized complete block design (RCBD) study with four replications was established on a creeping bentgrass research green to evaluate four herbicides, a standard hand-removal method, and a nontreated check for annual bluegrass control and creeping bentgrass response. Data were subjected to analysis of variance and means were separated with Fisher's Protected LSD test at $P = 0.05$. In an additional RCBD study, five targeted application devices were evaluated to examine differences in output volume and standard deviation of output from each device and replicated temporally 10 times. The targeted application devices examined included four dabbers and a handheld sprayer. The dabbers consisted of a small 1.7-cm-diameter bingo dabber, a Smucker Red Dabber®, a Weed Saber®, and a Weed Wand Magic® foam dabber. The handheld sprayer utilized was a Jerry's Weed Stick®. The output of the dabbers was calculated by dabbing water onto a golf green and measuring fluid loss after each 10 dabs until the dabber was emptied. Per-area calculations were based on the size of the foam applicator for dabbers and the average area of visibly evident spray pattern from the sprayer. The handheld sprayer was sprayed 50 times per replication into a graduated cylinder and fluid output was measured directly after every 10 sprays.In the field study, glyphosate (2.24 kg ai ha^{-1}), paclobutrazol (1.12 kg ai ha^{-1}), amicarbazone (0.20 kg ai ha^{-1}) and manual removal controlled annual bluegrass >87% and more than primisulfuron (0.08 kg ai ha^{-1}). Glyphosate and manual removal injured the creeping bentgrass turf >30% and were considered unacceptable. All other treatments injured creeping bentgrass turf <10%. Favoring our hypothesis, TADs varied greatly in application volume between devices, but contrary to our hypothesis, many of these devices also delivered inconsistent output between dabs. The Weed Wand Magic® deposited an average of 7100 L ha^{-1} which was significantly higher than all other devices. Jerry's Weed Stick® and the bingo dabber deposited the least volume at 3204 and 3960 L ha^{-1}, respectively. Statistical differences were also observed in the standard deviation of device output. The Weed Wand Magic® had a standard deviation of 4060 L ha^{-1} which was significantly higher than the deviation observed from all other devices. Dabbers had a higher standard error (SE) in application volume compared to the Jerry's Weed Stick sprayer SE of 6.1 L ha^{-1}. Application inconsistency among dabbers was found to be correlated to fluid level within the device. As fluid was depleted, fluid pressure likely decreased reducing the dabbing output. Output of all devices was 8 to 17 times greater than the industry standard (407 L ha^{-1}) for broadcast applications on greens.

Cotton Chromosome Substitution Lines, A Potential for Weed-Suppression. Worlanyo Segbefia*[1], Gracen Fuller[2], Tseng Te-Ming[2]; [1]Mississippi State University, Starkville, MS, [2]Mississippi State University, Mississippi State, MS (34)

Weed interference is a persistent danger to cotton production. In fact, among all agronomic problems crops face, weeds have the most severe effect. They raise production costs, degrade fiber quality, and act as breeding grounds for plant diseases. This study aims to find chromosomal replacement lines with weed-suppressive characteristics. A stair-step structure was used to experiment in the MSU greenhouse. First, two replications were performed using the Randomized Complete Block approach. Palmer amaranth (Amaranthus palmeri) is the most prevalent and damaging cottonweed in Mississippi. Because it is resistant to glyphosate and other herbicides, chemical weed management tactics must be supplemented. Allelopathy, a potential weed management strategy, employs secondary metabolites from a plant species to impede the growth and development of plants in the vicinity. To screen for weed-suppressive ability, backcrossed chromosome substitution (CS) lines were substituted for a homologous pair of G. hirsutum (TM-1) chromosome or chromosome arm of G. hirsutum. These CS lines were developed with a homologous pair of the chromosome or chromosome arms of G. barbadense (CS-B), G. tomentosum (CS-T), and G. mustellinum (CS-M). Eight of the 50 CS lines were examined in greenhouse experiments and field-tested to determine the level of Palmer amaranth suppression. Allelopathy is a crucial method for cotton weed suppression because it could be used as a substitute for synthetic herbicide. Also, this method could function as the base for producing other non-synthetic fertilizers.

CS Lines: A Solution for 2,4-D Drift in Conventional Cotton? Josiane C. Argenta*[1], Te-Ming (Paul) Tseng[2]; [1]Mississippi State University, Starkville, MS, [2]Mississippi State University, Mississippi State, MS (35)

Cotton is an essential fiber crop grown worldwide. The United States is the third biggest cotton producer, having a market value of 7 billion dollars. One of the major challenges in the cotton fields is the presence of resistant weed species that competes with the crop for light, water, and nutrients while reducing cotton yield and fiber quality. Herbicide-tolerant cotton has been developed to manage problematic weeds. However, the drift caused by the off-site movement of sub-lethal doses of 2,4-D to adjacent areas, where susceptible cultivars and other plant species are grown, is of extreme concern in agriculture. A practical tool to manage the off-target 2,4-D drift is the use of cotton chromosome substitution lines (CS lines). The cotton CS lines are non-transgenic and have retained the genetic diversity of different tetraploid cotton species (*Gossypium* spp.) that have been lost in the cultivated cotton varieties due to traditional breeding techniques. Therefore, the main goal of this research is to determine the genetic diversity among different CS lines, and between CS lines and cultivated cotton varieties, by using simple sequence repeat (SSR) markers and further identifying genes that can confer tolerance to sub-lethal rates of 2,4-D drift. The results obtained in this research will help breeding programs develop non-transgenic cotton tolerant to sub-lethal rates of 2,4-D.

CWSS Oral Contest

Effects of Winter Rye *(Secale Cereal*) Termination Strategies on Corn (*Zea mays*) Establishment, Weed Control and Yield. Olivia M. Noorenberghe*[1], Francois Tardif[1], Peter Sikkema[2], Mike Cowbrough[3], David Hooker[2], Peter Smith[1]; [1]University of Guelph, Guelph, ON, Canada, [2]University of Guelph, Ridgetown, ON, Canada, [3]OMAFRA, Guelph, ON, Canada (36)

Winter rye is a cover crop species that has many benefits in a cropping system; however, there are concerns that it negatively affects the corn crop that would follow in the rotation. The causes of this negative effect are unclear but may involve low quality light reflected by neighboring rye plants influencing corn seedlings. Three field experiments were conducted in southwestern Ontario in 2020 and 2021 to determine whether planting corn into rye free bands, or terminating rye with a fast-acting herbicide, can improve corn establishment while maximizing rye biomass. The hypothesis is that intensity of far-red enriched light perceived by corn seedlings is related to corn yield. Seedling growth and corn yield can be increased by planting into a rye free band and quickly terminating the rye. Treatments were solid seeded, and rye planted in double bands, two herbicides (glyphosate and glufosinate-ammonium), and four termination timings (14 days prior to 7 days after planting). Rye cover and biomass, light interception and quality, nitrogen availability, weed density and biomass and yield. Quality of transmitted light contributed to grain yield and the R:FR light ratio perceived by corn was reduced when planted into full planted rye compared to a rye free band which showed an increase in quality of light. A reduction in negative impacts through the utilization of herbicides which terminate rye faster could not be determined due to significant antagonism present between glyphosate and glufosinate. However, the rye cover crop will not reduce corn yields if rye is killed 7 to 14 d before corn planting. If waiting until 1 d before or 7 d after planting for rye termination, weed control does increase, however nitrate availability and light quality (reflected and transmitted) which may result in subsequent yield loss. However, in these trials, no significant yield decrease was observed amongst all termination timings.

A Growth Chamber Study - the Interaction of Trifludimoxazin + Saflufenacil and Pyroxasulfone for Control of False Cleavers (*Galium spurium*) and Wild Oat (*Avena fatua*).

Kathryn Aldridge*[1], Eric N. Johnson[1], Steve Shirtliffe[1], Ethan Bertholet[2], Mark Oostlander[3]; [1]University of Saskatchewan, Saskatoon, SK, Canada, [2]BASF Canada Inc., Saskatoon, SK, Canada, [3]BASF Canada Inc., Lethbridge, AB, Canada (37)

Alternative herbicide mechanisms of action (MOA) for weed control are needed due to the continuing development of herbicide-resistant (HR) weeds. The objectives of this study were to examine the herbicide interaction occurring between trifludimoxazin + saflufenacil (Group 14) and pyroxasulfone (Group 15) in false cleavers and wild oat and to determine the type of herbicide interaction present: additive, synergistic, antagonistic, or no effect. This study was conducted twice for each weed species in the phytotron facility at the University of Saskatchewan. Treatments comprised of two factors (herbicide group and rate), were applied in a randomized complete block design (RCBD) with four replicates. The false cleaver treatments for this study consisted of ten different rates (0.027778 – 16x, increasing in 2x increments) of BAS85100H (2:1 pre-mix of saflufenacil and trifludimoxazin (0.5, 1.125, 2.25, 4.5, 9, 18, 36, 72, 144, 288 g ai h^{-1}) and pyroxasulfone (1.666667, 3.75, 7.5, 15, 30, 60, 120, 240, 480, 960 g ai ha^{-1}) applied alone and as a tank-mix. The wild oat treatments consisted of nine different rates (0.125 – 32x, increasing in 2x increments) of BAS85100H (2.25, 4.5, 9, 18, 36, 72, 144, 288, 576 g ai h^{-1}) and pyroxasulfone (7.5, 15, 30, 60, 120, 240, 480, 960, 1920 g ai ha^{-1}) applied alone and as a tank-mix. Additional treatments included an untreated check. Herbicide efficacy ratings were taken 7, 14, and 21 days after emergence (DAE). A 3-parameter log-logistic model was selected for modelling the biomass of each weed species. For false cleavers, group 14+15 had the lowest ED50, the effective dose required to reduce the biomass present by 50%, at a 0.57x rate. Group 15 had the lowest ED50 at a 0.27x rate for wild oat but was not significantly different from group 14+15. Colby's equation was used to determine the type of herbicide interaction by comparing the expected and observed plant responses. A 3-parameter log-logistic model was selected for both weed species, and all model parameters were insignificant. This indicated an additive herbicide relationship, as the control for the herbicide mixture was equal to what was expected based on the two individual groups' efficacy. Utilizing a mixture of Group 14+15 herbicides improved false cleavers control compared to the individual groups. For wild oat, Group 14+15 performed similarly to Group 15, with the addition of Group 14 offering marginal improvements in efficacy. Overall, the HR weed management of false cleavers and wild oat was improved through tank-mixtures.

Evaluation of Clethodim for Management of Hair Fescue (Festuca Filiformis) and Red Fescue (Festuca Rubra) in Lowbush Blueberry Fields in Atlantic Canada. Tyler MacLean*[1], Scott N. White[2], Andrew McKenzie-Gopsill[3], Travis J. Esau[1]; [1]Dalhousie University, Bible Hill, NS, Canada, [2]Dalhousie University, East Mountain, NS, Canada, [3]Agriculture and Agri-Food Canada, Charlottetown, PE, Canada (38)

Evaluation of clethodim for management of hair fescue (Festuca filiformis) and red fescue (Festuca rubra) in lowbush blueberry fields in Atlantic CanadaTyler MacLean, Scott White, Andrew McKenzie-Gopsill, Travis EsauHair fescue is found in 75% of lowbush blueberry fields in Nova Scotia and reduces yield by up to 50%. Pronamide is the only herbicide currently providing effective control during the full two year growing cycle and foramsulfuron provides suppression in the non-bearing year only. Additional herbicide treatments are needed to reduce growers' reliance on pronamide and prevent the development of resistant biotypes. Clethodim previously suppressed hair fescue in a limited number of non-bearing year fields, suggesting this herbicide may contribute to hair fescue management. . The objectives of this research were to 1) determine clethodim efficacy on multiple hair fescue populations in Nova Scotia, 2) determine the bearing year efficacy of clethodim on hair fescue, and 3) determine the effect of clethodim application rate on hair fescue using a dose response experiment. Clethodim was applied at 91.2 g a.i. ha^{-1} with 2000ml Amigo surfactant ha^{-1} for objectives 1 and 2 and at 0, 0.25, 0.5, 1, 2, 4, 8, and 16X (X = 45.6g a.i. ha^{-1}) with 2000ml Amigo surfactant ha^{-1} for objective 3. Clethodim reduced hair fescue flower tuft density and tuft inflorescence number in 6 of 8 non-bearing year populations evaluated and reduced flower tuft density and tuft influence number at all bearing year sites evaluated. The anticipated label rate of 91.2 g clethodim ha^{1} reduced flower tuft density by 81, 95, and 95% at the three dose response sites, suggesting this application rate is likely sufficient for hair fescue suppression in lowbush blueberry. The anticipated registration of clethodim in lowbush blueberry should therefore provide a new herbicide site of action for hair fescue management for the entire growing cycle.

When Using Glyphosate Plus Dicamba, 2,4-D Ester, Halauxifen-Methyl or Pyraflufen-ethyl/2,4-D for Glyphosate-Resistant Horseweed (*Erigeron canadensis*) Control in Soybean, Which Third Tankmix Partner is Better, Saflufenacil or Metribuzin? Meghan E. Dilliott*, Nader Soltani, David C. Hooker, Darren E. Robinson, Peter Sikkema; University of Guelph, Ridgetown, ON, Canada (39)

Horseweed is a dicot weed native to North America. Repeated applications of glyphosate have resulted in the rapid evolution of glyphosate-resistant (GR) horseweed. GR horseweed interference in soybean can reduce yield up to 93%. Glyphosate plus dicamba, 2,4-D ester, halauxifen-methyl or pyraflufen-ethyl/2,4-D applied preplant (PP) provide variable GR horseweed control in soybean. The objective of the study was to determine if the addition of saflufenacil or metribuzin to glyphosate plus dicamba, 2,4-D ester, halauxifen-methyl or pyraflufen-ethyl/2,4-D will improve the level and consistency of GR horseweed control. Four trials were conducted over the 2020 and 2021 field seasons in fields with GR horseweed populations. Glyphosate plus dicamba, 2,4-D ester, halauxifen-methyl or pyraflufen-ethyl/2,4-D controlled GR horseweed 96, 77, 71, and 52%, respectively at 8 weeks after application (WAA). When saflufenacil or metribuzin was added to glyphosate plus dicamba or 2,4-D ester GR horseweed control did not improve 8 WAA. When saflufenacil or metribuzin was added to glyphosate plus halauxifen-methyl GR horseweed control improved by 27 and 25%, respectively 8 WAA. When saflufenacil or metribuzin was added to glyphosate plus pyraflufen-ethyl/2,4-D GR horseweed control was improved by 47 and 37%, respectively 8 WAA. The consistency of GR horseweed control was improved when saflufenacil or metribuzin was added to glyphosate plus dicamba, 2,4-D ester, halauxifen-methyl or pyraflufen-ethyl/2,4-D compared to each herbicide applied alone. Synergism was observed when metribuzin was added to glyphosate plus halauxifen-methyl and when saflufenacil or metribuzin was added to glyphosate plus pyraflufen-ethyl/2,4-D 8 WAA; interactions between the other tankmix partners were mostly additive.

Tolerance of Four Dry Bean Market Classes (*Phaseolus vulgaris* and *Vigna angularis*) to Flufenacet, Acetochlor and *S*-Metolachlor Applied Preplant Incorporated. Hannah E. Symington*[1], Allan Kaastra[2], David Hooker[3], Darren E. Robinson[3], Peter Sikkema[3]; [1]University of Guelph, Rr#3 Watford, ON, Canada, [2]Bayer Crop Science, Guelph, ON, Canada, [3]University of Guelph, Ridgetown, ON, Canada (40)

Common bean (*Phaseolus vulgaris* L.) and azuki bean (*Vigna angularis* (Willd.) Ohwi & H. Ohashi) are poor competitors with weeds and are sensitive to many herbicides registered for weed control in soybean (*Glycine max*). Flufenacet and acetochlor are Group 15 herbicides that control many annual grass and some small-seeded annual broadleaf weeds. Field trials were conducted near Exeter and Ridgetown, ON in 2019, 2020, and 2021 to evaluate the tolerance of four market classes of dry bean (azuki, kidney, small red, and white bean) to 1X and 2X labelled/proposed label rates of flufenacet (750 and 1,500 g ai ha^{-1}), acetochlor (1,700 and 3,400 g ai ha^{-1}) and *S*-metolachlor (1,600 and 3,200 g ai ha^{-1}) applied preplant incorporated (PPI). Visible injury by symptom, height, density, shoot biomass, seed moisture content, and seed yield were evaluated. Azuki bean was more sensitive to the Group 15 herbicides than other dry bean market classes; the Group 15 herbicides caused a 12% reduction in azuki bean growth at 1 week after emergence; growth reduction was =2% in the kidney, small red and white beans. Flufenacet (2X rate) was the most injurious treatment causing a 27% reduction in azuki bean yield. This study concludes that kidney, small red, and white bean have an adequate margin of safety to flufenacet, acetochlor, and *S*-metolachlor applied PPI. Azuki bean was sensitive to flufenacet; further research is needed to ascertain the tolerance of azuki bean to acetochlor and *S*-metolachlor applied PPI.

How Much Will Climate Change Increase Habitat Suitability of Four Relatively New Invasive Plant Species in the Pacific Northwest? Emma K. Nikkel*[1], David R. Clements[2], Jennifer L. Williams[1]; [1]University of British Columbia, Vancouver, BC, Canada, [2]Trinity Western University, Langley, BC, Canada (41)

Effects of climate change on the habitat suitability of 4 relatively new invasive plant species in the Pacific Northwest Emma K. Nikkel, David R. Clements, and Jennifer L. Williams Invasive species are a substantial threat to biodiversity and ecosystem structure. This threat is exacerbated by the increasingly concerning and urgent outlook of predicted climate change, land cover change, and other human influences. Specifically, an increasing number of invasive plant species are spreading in the Pacific Northwest (PNW), an area of unique natural areas, economic value, and increasing human population. Predicting the potential habitat suitability of plant species on the 'prevention' or EDRR (early detection and rapid response) lists is crucial for developing preventative management strategies. To this end, we have developed habitat suitability models for four EDRR invasive plant species, two terrestrial species: shiny geranium (Geranium lucidum) and mouse-ear hawkweed (Hieracium pilosella); and two aquatic species: water hyacinth (Eichhornia crassipes) and flowering rush (Butomus umbellatus), predicting the potential current and future habitat suitability for each species. For each species, 33 bioclimatic variables, 10 land cover types, and a human influence index were initially considered in model building. We projected each species' habitat suitability using ensemble modelling (from six algorithms, including random forest and generalized linear models) to 2050 and 2080, under 3 SSP-RCP scenarios from the IPCC 6th assessment. The majority of the coastal PNW is predicted to remain potential habitat for shiny geranium under all future climate scenarios, with some loss of habitat suitability in its southern range limits. In contrast, mouse-ear hawkweed, while currently suited to most inland regions of the PNW, is predicted to lose the majority of potentially highly suitable habitats by 2050 under all climate scenarios, retaining only high elevations as potential habitat. Potential future habitat suitability remains relatively unchanged for water hyacinth. Unlike water hyacinth, which is highly suitable for inland waterways that do not experience freezing temperatures, the suitable range for flowering rush in the PNW is currently only moderately suitable. Overall, the bioclimatic and human influence (population density, infrastructure, and human access) variables were more important than land cover variables; however, the inclusion of bioclimatic variables were consistently the most important across all models, suggesting that climate change is the determining factor for the change in suitable habitat. Our results can assist local land managers and practitioners to inform current and future management strategies and practices and increase the efficiency of allocating limited resources toward those species with expanding ranges.

Clonal Growth Dynamics After Girdling Treatments in *Reynoutria* spp. Ecotypes. Vanessa L. Jones*[1], Aidan R. Anderson[2], David R. Clements[2]; [1]University of British Columbia, Vancouver, BC, Canada, [2]Trinity Western University, Langley, BC, Canada (42)

Alien plant invasions are increasingly recognized as global issues resulting in significant landscape-level changes. Though clonal growth is often associated with invasive success in plants many aspects of its role are still unclear. Bohemian and Japanese knotweed are vigorous clonal invaders now widely distributed across North America. Currently, application of herbicides is the most common, efficient and cost-effective means of knotweed control. However, in the province of British Columbia, the use of herbicides is sometimes restricted, leaving large proportions of knotweed in riparian areas untreated. Yet waterways are a major vector of spread and water immersion can increase the duration of viability of seeds and rhizome fragments. A non-herbicide method first used in BC in 2018 involves girdling of the knotweed stems by placing a wire mesh on the ground in early spring prior to emergence of new stems. As the stems grow through holes in the mesh, they eventually become too large, and the wire mesh girdles the stems, causing mortality or reduced growth. To quantify the effect of the mesh on above-ground knotweed foliage, five knotweed sites in the Lower Mainland of BC were selected, and two sizes of wire mesh installed in the spring of 2021. Percent coverage of shoots, proportion of living and dead shoots, presence or absence of flowers, average height, and degree of girdling were recorded every two weeks until the end of the growing season. To test impacts on the below-ground rhizome, knotweed plants were grown from rhizome fragments in pots covered in the two sizes of mesh. In addition to observations of the foliage, observations of the rhizome (biomass, spacer length, entire rhizome length, number of rhizome branches, and number of ramets) were taken every two weeks until the end of the growing season. After one season we observed a reduction in shoot height and cover in field sites. Preliminary results from the potted rhizomes were inconclusive due to low viability and growth of rhizome samples. Ascertaining how rhizomes respond to different mesh treatments could inform whether this method provides long-term control. With more testing, this new control method, wire mesh girdling, could prove to be an effective strategy for controlling riparian knotweed throughout the province of BC, filling gaps where pesticide use is prohibited.

Interaction of 4-hydroxyphenylpyruvate Dioxygenase (HPPD)-Inhibiting and Reactive Oxygen Species (ROS)-Generating Herbicides for the Control of Annual Weed Species in Corn. John C. Fluttert*[1], Mariano Galla[2], David C. Hooker[1], Darren E. Robinson[1], Peter Sikkema[1]; [1]University of Guelph, Ridgetown, ON, Canada, [2]ISK Biosciences, Concord, OH (44)

The interaction between 4-hydroxyphenylpyruvate dioxygenase (HPPD)-inhibiting herbicides and photosystem II (PSII)-inhibiting herbicides has been documented. Herbicides that inhibit HPPD reduce the ability of a plant to quench reactive oxygen species (ROS) while PSII-inhibitors upregulate the production of ROS which can ultimately cause cell death by lipid peroxidation. The interrelated modes of action of HPPD- and PSII-inhibitors has been credited for the synergistic interaction between the two herbicides for the control of several weed species; however, additive interactions between the herbicides are also common. Recent research has identified that ROS generation and subsequent lipid peroxidation is the cause of cell death by the glutamine synthetase-inhibitor, glufosinate. Therefore, a basis for synergy exists between glufosinate and HPPD-inhibitors; however, the interaction has not been intensively studied. Four field trials were conducted in southwestern Ontario, Canada in 2020 and 2021 to determine the interaction between HPPD-inhibiting (mesotrione and tolpyralate) and ROS-generating (atrazine, bromoxynil, bentazon, and glufosinate) herbicides for the control of several annual weed species in corn (*Zea mays* L.). Tank-mixes of HPPD-inhibitors + ROS-generators were synergistic for the control of common ragweed (*Ambrosia artemisiifolia* L.) except for tolpyralate + glufosinate which was antagonistic 8 weeks after application (WAA). Tolpyralate + glufosinate was also antagonistic for the control of *Setaria* spp. at 8 WAA. All herbicide tank-mixes were additive for the control of wild mustard (*Sinapis arvensis* L.) at 8 WAA except for the synergistic tank-mixes of tolpyralate plus atrazine or bromoxynil. Results from this research demonstrated that ROS-generators plus mesotrione or tolpyralate controlled common ragweed and wild mustard >90% at 8 WAA except for common ragweed control with tolpyralate + glufosinate. Glufosinate was the best tank-mix partner with mesotrione for the control of *Setaria* spp. at 8 WAA. Tolpyralate tank-mixed with any ROS-generator controlled *Setaria* spp. equivalently at 8 WAA.

Cultural Weed Management in Irrigated Soybean. Shamini Dilshadi Jayasekara*; University of Lethbridge, Lethbridge, AB, Canada (45)

Cultural Weed Management in Irrigated Soybean. Shamini D Jayasekara[1] , Charles M Geddes[2] , 1.University of Lethbridge, Faculty of Art and Science 2. Agriculture and Agri-Food Canada, Lethbridge Research and Development Centre Soybean [*Glycine max* (L.) Merr.] have grown to be an important nitrogen-fixing legume crop in the predominant cereal-oilseed crop rotations practiced in western Canada due the development of short-season soybean cultivars that better suit this region. However, this crop continues to exhibit delayed emergence and early growth compared with many problematic weeds in this region, resulting in greater reliance on herbicides for weed control and concomitant selection pressure for herbicide resistance. Two field experiments were implemented near Lethbridge, Alberta, in 2020 and 2021 to determine how four cultural weed management tools impact soybean productivity and competitiveness with weeds. The experiment followed a split-block randomized complete block design with a four-way factorial treatment structure, including (i) soybean row spacing [23 cm vs. 68 cm], (ii) seeding density (400,000 vs. 600,000 target plants ha^{-1}), (iii) cultivar (bushy vs. slender), and (iv) fall rye cover cropping (presence vs. absence). The blocks were split to create both weedy and weed-free subplots. Under weed-free conditions, the higher seeding density improved soybean yield by 6% for the slender but not the bushy cultivar. Soybean grown in narrow rows at the higher density resulted in the greatest yield under weed interference. Soybean grown in narrow rows exhibited 18.3% yield loss due to weed interference compared with 81.7% yield loss when grown in wide rows. The fall rye cover crop terminated with the pre-plant burndown herbicide did not impact soybean yield under weedy or weed-free conditions, but did reduce weed biomass in 2021 by 13.7% compared with no cover crop. The fall rye cover crop reduced surface soil NO_3-N supply by 22% on average for the first 10 weeks of soybean growth resulting lower N available to weeds compared with the absence of a cover crop. In conclusion, planting irrigated soybean in narrow rows at higher densities into a fall rye cover crop could improve soybean productivity and ability to withstand weed interference in southern Alberta.

Impact of Low R/FR Light Environments on Nitrogen Assimilation in Maize (*Zea mays*).
William Kramer*[1], Clarence Swanton[2], Francois Tardif[1]; [1]University of Guelph, Guelph, ON, Canada, [2]University of Guelph, Guelph, AZ, Canada (46)

In the absence of direct resource competition, far-red light reflected from neighbouring weeds compromises light quality (red to far-red ratio; R/FR) which inactivates phytochrome (Phy) resulting in the regulation of various physiological processes. The main objective of this research was to investigate the effects of low R/FR light on nitrogen assimilation in corn. To explore this, changes to the nitrogen assimilation pathway were measured in corn seedlings nine days post-emergence under low R/FR and control light conditions. The observed results indicate that nitrate levels increased and ferredoxin-dependent glutamine:2-oxoglutarate aminotransferase activities decreased under low R/FR light, however, no other pathway enzymes were affected. Changes in the pathway appear to be PhyB-independent, as Arabidopsis *phyB* mutant did not change the nitrate levels compared to wild-type Arabidopsis. The research indicates the importance of mitigating early-season weed competition and offers insight into the early physiological mechanisms involved in nitrogen utilization under resource-independent competition.

WSSA Student Travel Enrichment Experience

Paraquat, Peanuts, and Ponies: A Week with Syngenta's State Regulatory Group. Devon E. Carroll*; University of Tennessee, Knoxville, TN (47)

Each year, the Weed Science Society of America awards students funding to participate in a week-long experiential learning opportunity titled the Travel Enrichment Experience. In 2021, Devon Carroll, a doctoral candidate at the University of Tennessee, was awarded one of five Travel Enrichment Experience stipends. She chose to shadow Dr. Carroll Moseley, Head of State Regulatory Affairs & Stewardship for Syngenta. Devon traveled to the U.S. Syngenta Crop Protection headquarters in Greensboro, NC from October 4^{th}-8^{th}, 2021. While visiting Dr. Moseley, Devon was exposed to a new side of weed science beyond product development by learning about herbicide regulation and registration. She also explored other industry career opportunities by networking with Syngenta professionals working on teams in marketing, technical services, and field development. The trip included a wide variety of learning experiences such as observing regulatory affairs meetings, recording a War Against Weeds podcast, visiting North Carolina State University research collaborators, touring the Duke family tobacco homestead, and attending an Environmental Protection Agency pesticide inspectors workshop in Ocean City, MD. Devon's time with Dr. Moseley solidified her decision to pursue an industry rather than academic position following her graduation. Devon is grateful for the generosity of the Weed Science Society of America, Dr. Moseley, and Syngenta for providing her this opportunity.

Potatoes and a Pandemic: 2020 Travel Enrichment Experience with Syngenta R&D in Idaho. Delaney C. Foster*; University of Tennessee, Jackson, TN (49)

2020 Travel Enrichment Experience to visit Dr. Marty Schraer with Syngenta Crop Protection in Boise, Idaho. Highlights of the trip included an ASR drone demonstration, visiting the University of Idaho's Kimberly research and education center, harvesting lentils, visiting a hops grower and more.

The Vastness of California Agriculture - My Travel Enrichment Experience with Corteva Agriscience. Matthew Osterholt*; Purdue University, West Lafayette, IN (50)

As a recipient of the 2021 WSSA Travel Enrichment Experience, I was granted the opportunity to travel to Woodland, California to spend four days with Dr. Marc Fisher and his team. Dr. Fisher, who serves as a the Field Science Leader for the North and Western United States for Corteva Agrisciences, was able to provide me firsthand experience and look into the day-to-day life someone manages field scientist. The first two days of my trip were spent at the Woodland research farm where I was able to shadow three field scientists that worked on station. The first thing I noticed when I arrived was the diversity of crops that were being grown that included rice, corn, sunflower, lettuce, broccoli, onions, tomatoes, and a variety of orchard crops to just name few! The team demonstrated that the life of a successful industry scientist requires not just expertise in weed science, but also an overall understanding of agronomics, entomology, pathology, and nematology as well. On the third day, I traveled to Fresno where I attend a training event with field scientist Stephen Colbert. At the event was the sales and marketing team to discuss a novel nematicide that Corteva is hoping to commercialize for use in orchards and a variety of other crops. It was great to listen to the conversation between Stephen and the marketing team as they discussed the utility, performance, and positing within the market for their novel nematicide. The fourth day I traveled to the coast where I traveled with Kunle, a remote field scientist, to several of his field trials. Kunle demonstrated the importance of strong personal skills, managing time and data, and ability to solve problems that arise in the field, and are traits that I hope to emulate in my future. I truly appreciate the hospitality I received from Dr. Fisher and his team during my trip, as well as the funding from the WSSA in support of the Travel Enrichment Experience, and strongly encourage other graduate students to apply for this unique opportunity in the future.

Syngenta's Integrated Approaches to Solve Challenges in Weed Science: 2021 Travel Enrichment Experience. Ramawatar Yadav*[1], Ethan T. Parker[2], Jason W. Adams[2], Rakesh Jain[2], John R. Brewer[2], Jason Eaton[2]; [1]Iowa State University, Ames, IA, [2]Syngenta Crop Protection, Vero Beach, FL (51)

In today's fast-growing science, staying current in the field of interest is utmost important to be innovative. Although I was actively involved in university-based research programs, I was seeking for opportunities to explore weed science research facilities and activities in an industry setting. Agricultural-chemical industry has been benefiting weed science and farming community for decades by providing effective weed control options. However, in response to mounting cases of herbicide resistant (HR) weeds, industry has been changing their proactive strategies to develop integrated systems. The 2021 Travel Enrichment Experience Award sponsored my trip to visit Syngenta's research center in Vero Beach, Florida for one week. Vero Beach Research Center supports research and development in the field of weed science, entomology, and plant pathology. During my visit, I worked in weed science facility under the supervision of Dr. Ethan Parker, a Research and Development Leader for the weed science group. I also worked with three other Weed Scientist from Dr. Parker's team. This facility works on detecting herbicide resistance, optimizing activity of existing herbicides products, and testing of herbicides with new sites-of-action at early-development stage. Additionally, the facility works on development and evaluation of technologies such as mechanical weed control, early-detection of HR weeds using unmanned aerial vehicles, and precision sprayers. While working on these projects, I also learned about different ways of approaching various weed-related problems. This travel experience helped me to sharpen my research skills and knowledge in the area of weed science, and to establish professional contacts and collaborations between industry and academia in my future career as a Weed Scientist.

From Michigan to Tennessee: A Week in the Life of a Technical Service Representative.
Justine L. Fisher*; Michigan State University, East Lansing, MI (52)

The WSSA Travel Enrichment Experience has provided weed science students with invaluable experiences. As one of the 2021 recipients, I had the opportunity to learn more about the inner workings of being a Technical Service Representative and Biologist with BASF. In July I travelled to Tennessee, Kentucky, and Missouri and was fortunate enough to visit with Dr. Greg Stapleton and Dr. Cletus Youmans who serve as a Technical Service Representative and Biologist with BASF. They provided me with a firsthand look at day-to-day life of their respective roles as well as gave me the opportunity to interact with a sales representative, technical service manager, and their academic partners. First, I got the opportunity to visit the agricultural hub of the Mid-South in Memphis, Tennessee that conducts over 250 research trials for more than 60 companies, including BASF. Agricenter International works with agribusinesses, universities, the government, and other organizations to conduct research on agricultural products and technologies. During this visit I discovered that Tennessee produces a variety of crops outside of corn and soybean, including cotton and tobacco. I also learned that even though Michigan and Tennessee produce different crops, both states have similar weed management issues, including multiple herbicide-resistant Palmer amaranth and waterhemp. I got to see firsthand how detrimental these weeds can be in soybean and cotton at the West Tennessee AgResearch and Education Center where we visited with Extension Weed Specialist, Dr. Larry Steckel, and viewed several research trials they were conducting on cotton and soybean. Next, we visited trials in Missouri and Kentucky and interacted with local retailers and gained a better understanding of the issues they face. On a farm call, I observed herbicide drift in soybean and learned how to handle a customer service call. During my visit, I learned that in the life of an industry professional, communication is key to being successful as well as the drive to keep learning especially as we face more agronomic, and more specifically weed management, challenges. The opportunity to visit professionals that worked for BASF provided me a week of education and gave me a better understanding of what my future career may look like and how I can best succeed in one of those roles. I am grateful for the hospitality I received from Dr. Greg Stapleton and Dr. Cletus Youmans and I encourage all graduate students to apply for these opportunities.

A Tale of Two States. Nicholas L. Hurdle*; University of Georgia, Tifton, GA (53)

In the summer of 2021, with thanks to the WSSA Graduate Student Travel Enrichment Exerience award, I was able to travel over 1,000 miles into the heart of Northeastern United States agriculture. I was fortunate to visit with Drs. Erin Hitchner and Larissa Smith in New Jersey and New York, respectively, and tour Syngenta research sites and cooperator research locations. During this experience, I wanted to understand the agriculture industry in the NE United States and see a plethora of crops not grown in South Georgia. While in N.J. and N.Y., I spent time with a variety of people in various positions within industry and academia, as well as disciplines other than weed science. From weed management in cranberry to nematode control in vegetables, my time in New Jersey was spent learning about the diverse cropping systems in the region. From weed zappers to goats in weed science, the diversity of weed management techniques were incredible to see utilized as compared to chemical control alone. I am extremely thankful for this experience and the hospitality of Drs. Erin Hitchner and Larissa Smith and their respective staff and students.

MS Student Poster Contest

Evaluation of Herbicide Application Timing and Sequence for Weed Control in Soybean.
Navjot Singh*[1], Ryan P. Miller[1], Thomas J. Peters[2], Seth L. Naeve[1], Debalin Sarangi[3]; [1]University of Minnesota, Saint Paul, MN, [2]North Dakota State University, Fargo, ND, [3]University of Minnesota, St. Paul, MN (54)

The introduction of multiple herbicide-resistant soybean such as Enlist E3® soybean (resistant to 2,4-D choline, glyphosate, and glufosinate) is allowing growers to spray POST herbicides that are considered lethal to non-genetically engineered soybean. Application of herbicides at right time and in a proper sequence can control weeds effectively and minimize soybean yield losses. The objective of this research was to evaluate the effect of POST herbicide application timing and sequence on weed control and Enlist E3® soybean yield. Field experiments were conducted at Franklin, and Rosemount, MN, in 2021. Treatments were arranged in a factorial-randomized complete block design, where one factor was PRE herbicide (acetochlor) application and the second factor was POST herbicide application timing and sequence. POST herbicides were applied at V1 (early-POST), V3 (mid-POST), and R1 (late-POST) stages of soybean. Acetochlor applied PRE provided = 97% waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] control at 21 d after PRE (DAPRE) at both sites, whereas, common lambsquarters (*Chenopodium album* L.) control was 80% and 58% at Franklin and Rosemount, respectively, at that time. At 28 d after late-POST (DALP), POST-only glufosinate treatment showed 70% waterhemp control at Rosemount, whereas, PRE-only treatment of acetochlor had better waterhemp control (90%) at that time. Regardless of the PRE herbicide treatment, glufosinate applied POST resulted in = 65% common lambsquarters control at 28 DALP at Rosemount. No difference in waterhemp control (= 97%) and density (= 1plant m^{-2}) were observed at 28 DALP if the POST herbicide treatments were made following a PRE application. Averaged across the treatments, soybean yield was significantly higher in PRE *fb* POST treatments (4,412 and 2,215 kg ha^{-1} in Franklin and Rosemount, respectively) than POST-only treatments (4,088 and 1,244 kg ha^{-1}). The results indicated that an application of PRE herbicide was important for waterhemp control, and the POST-only treatments of glufosinate were not sufficient for season-long weed control in Enlist E3® soybean.

Crop Response and Control of *Amaranthus palmeri* in Isoxaflutole-based Cotton Systems.
Maxwell E. Smith*[1], Peter A. Dotray[2], Adam Hixson[3]; [1]Texas Tech University, Lubbock, TX, [2]Texas Tech University and Texas A&M University, Lubbock, TX, [3]BASF Corporation, Lubbock, TX (55)

Amaranthus palmeri S. Wats. (aka Palmer amaranth, Palmer pigweed, carelessweed) is the most common weed and now one of the most troublesome weeds on the Texas Southern High Plains. The development of glyphosate-tolerant *Amaranthus palmeri* presents new challenges to producers when it comes to controlling this troublesome weed in crop production. HPPD-tolerant cotton from BASF will soon be available and allow producers to use a new mode of action in cotton (*Gossypium hirsutum* L.). In 2021, a field study was conducted at the Texas Tech University New Deal Research Farm (New Deal, Texas) to evaluate herbicide programs in cotton utilizing the HPPD-inhibiting herbicide isoxaflutole. The objective of the study was to evaluate crop response and the control of *Amaranthus palmeri* in HPPD-tolerant cotton systems using isoxaflutole. *Amaranthus palmeri* control and cotton response were evaluated after preemergence and early-postemergence applications of different herbicide programs, many of which included isoxaflutole. The herbicide programs that included isoxaflutole were compared to locally appropriate herbicide programs. Cotton crop response 21 days after the preemergence application was less than or equal to 12% for all treatments. Cotton crop response 14 days after the early-postemergence application was less than or equal to 14% for all treatments. Control of *Amaranthus palmeri* 29 days after the preemergence application was greater than or equal to 92% for all treatments that included isoxaflutole and less than or equal to 88 percent for all treatments that did not include isoxaflutole. Control of *Amaranthus palmeri* 28 days after the early postemergence application was greater than or equal to 88% for all treatments that included a full 1X field rate of isoxaflutole in the preemergence application. Cotton lint yields for all treatments were greater than or equal to 1,468 kg ha^{-1} except for the weedy control. New HPPD-tolerant cotton offers a new mode of action for use in cotton and will aid in the residual control of *Amaranthus palmeri* and other troublesome weeds.

Effect of Sub-lethal Rates of Glyphosate on Quizalofop-Resistant Rice Tolerance to Quizalofop. Navdeep Godara*, Jason K. Norsworthy; University of Arkansas, Fayetteville, AR (56)

Quizalofop-resistant rice technology became commercially available for Midsouth growers in 2018 and was followed by injury to quizalofop-resistant cultivars from postemergence applications of quizalofop. Rice is grown in close association with glyphosate-resistant corn, cotton, and soybean, increasing the risk of injury to rice hectares through non-target glyphosate drift. Field experiments were conducted in 2021 at Colt and Keiser, AR, to determine if the sub-lethal rate of glyphosate interacts with sequential quizalofop application to increase the risk for injury to quizalofop-resistant rice cultivar, PVL02 over applications of quizalofop alone. Experiments were implemented as a split-plot design, with location as a whole-plot factor, and herbicide treatment (glyphosate followed by initial quizalofop application at 10, 7, 4, 0-day interval and glyphosate applied alone at 10, 7, 4, 0-day interval before initial quizalofop application) as a split-plot factor. Glyphosate was applied at 90 g ae/ha, 1/10X of labeled use rate in soybean, and sequential quizalofop applications were at the recommended use rate of 120 g ai/ha applied at the 2-leaf stage followed by the 5-leaf stage. At 28 days after treatment (DAT), glyphosate followed by initial quizalofop at 0-day interval caused 18 percentage points more injury than glyphosate applied alone at 0-day interval regardless of location. In addition, glyphosate followed by initial quizalofop at the 0-day interval had a significantly higher glyphosate concentration in leaf tissue samples than glyphosate applied alone at the 0-day interval when analyzed at 7 DAT for both locations. Furthermore, rough rice grain yield was reduced to 34% when glyphosate application was followed by quizalofop application at 0-day interval compared with glyphosate applied alone at the 0-day interval at Colt, AR. Overall, glyphosate followed by quizalofop applications exacerbates injury over sequential quizalofop application alone, and as the timing interval between sub-lethal exposure to glyphosate and quizalofop application shorten, the detrimental affect to quizalofop-resistant rice increases.

Evaluation of Corn Harvest Loss in Southeastern and South Central Nebraska. Trey P. Stephens*; University of Nebraska-Lincoln, Lincoln, NE (57)

Evaluation of corn harvest loss in Southeastern and South Central Nebraska Trey Stephens, Jennifer Rees, Amit Jhala University of Nebraska-Lincoln The abundance of volunteer corn in production fields can be seen across Nebraska in recent years, due in part to the adoption of herbicide-resistant (HR) hybrids, and reduced tillage practices. With commercialization of multiple HR hybrids, persistence of volunteer corn in soybean rotations is of main concern. In 2020 and 2021 a total of 47 fields, 26 and 21 fields respectively, were hand-sampled across corn production fields in southeastern and south-central Nebraska post-harvest. The objective of these samples was to determine the relationship of harvest loss with volunteer corn seed bank additions. In each field, 16 samples of loose kernels and ears were collected from 0.5 m2 quadrat, with 100 count seed weight calculated and adjusted to 15.5% moisture content. Analysis of all samples indicated harvest losses of 195.5 and 196.5 kg ha–1 for dryland and irrigated corn in 2020 and losses of 81.1 and 93.8 kg ha–1 in 2021. While yield from individual fields are not currently available for all sampled locations, harvest loss measured in 2020 equates to 1.5% in irrigated systems and 2% in dryland systems and in 2021, 0.7% in irrigated systems and 0.8% in dryland systems based on the statewide yield (13,382 and 9,885 kg ha–1, respectively) in 2017. Germination rates for 2020 equate to 51%, therefor a mean of 8.42 viable seeds/m-2 are added to the seedbank in all fields sampled. Germination tests are still being conducted to determine 2021 seed bank addition and analysis to predict seedbank additions will calculated using predictive modeling.

Weed Control and Rice Response to Pyraclonil, A New Broad-Spectrum Herbicide in California Rice. Sarsh L. Marsh*, Aaron Becerra-Alvarez, Alex R. Ceseski, Saul Estrada, Kassim Al-Khatib; University of California, Davis, CA (58)

California rice (*Oryza sativa*) production faces more herbicide-resistant weeds than any other crop or region in the United States, and new weed management tools are needed. Pyraclonil (Nichino America Inc.) is a new PPO-inhibiting active ingredient which is being evaluated in California water-seeded rice. This new chemistry has activity on a broad spectrum of rice weeds such as early and late watergrass (*Echinochloa spp.*), smallflower umbrellasedge (*Cyperus difformis*), ricefield bulrush (*Scirpus mucronatus*), and ducksalad (*Heteranthera spp.*) which are present in many California rice fields. NAI-1883 (a granular formulation of 1.8% pyraclonil) was evaluated in combination with other herbicides to access the efficacy and rice response of a season-long herbicide program. The programs included NAI-1883 at 300 g ai ha^{-1} applied the day of seeding in combination with propanil, clomazone, benzobicyclon+halosulfuron, thiobencarb, bispyribac-sodium, penoxsulam, florpyrauxifen-benzyl, and cyhalofop at their respective timing later in the season. Rice injury from NAI-1883 was minimal. The herbicide program of NAI-1883 followed by benzobicyclon+halosulfuron and propanil showed exceptional control of all weeds by 45 days after seeding (100% control). All other treatments showed effective weed control. The program consisting of NAI-1883 followed by propanil was effective in controlling a majority of weeds but recorded reduced control of early and late watergrass (<89% control) and ricefield bulrush (87% control). Harvest evaluations recorded acceptable yields for all pyraclonil treatments, ranging from 10913.73 kg ha^{-1} to 12179.17 kg ha^{-1}. As an additional tool for California weed control, pyraclonil shows effective weed control and minimal injury on rice.

Physiological and Microbiological Impact of Dicamba on Tolerant Soybean. Francielli S de Oliveira*[1], Pablo A de Sousa[2], Lucas G. Panciera[3], Guilherme Chudzik[4], Robson J N de Lima[3], Pedro J. Christoffoleti[5]; [1]University of São Paulo, Limeira, Brazil, [2]University of São Paulo, Teresina, Brazil, [3]University of São Paulo, Piracicaba, Brazil, [4]University of Wisconsin-Madison, Madison, WI, [5]University of Sao Paulo, Piracicaba, Brazil (59)

The knowledge on the adverse effects of post-emergence herbicides on beneficial microorganisms to crops is essential for modern agricultural practices, especially on the newly realized tolerant crops to auxin herbicides. However, it is unknown scientifically if the dicamba, applied on tolerant soybeans to dicamba (DT), affects the arbuscular mycorrhizal (AM) and biological nitrogen fixation (BNF) colonization. Therefore, the objective of the research was to verify the effect of dicamba post-emergence application on DT soybean, under two nutritional conditions, on BNF and AM colonization. A greenhouse trial was conducted in a randomized block design, with a 2x2 factorial arrangement, with four replications. The first factor was dicamba application (480 g a.e. ha^{-1}) and the control without application. The second factor was the nutritional condition supplied, being mono ammonium phosphate (MAP) at 170 kg ha^{-1}, applied at crop seeding, followed by potassium chloride (KCl) side dressed application at 60 kg ha^{-1} (base fertilization), and the other mode was the base fertilization, supplemented by foliar micronutrient applications at V4 and R1 (complete fertilization). BNF was measured by nodule dry mass, and leaf nitrogen content. The rate of AM colonization and leaf phosphorus content was used to determine the AM status. Plant height, dry weight of root, and stem system measured plant development. Physiological conditions were measured by the chlorophyll index and maximum quantum yield. Data were subjected to analysis of variance using ANOVA on RStudio and means separated using the Tukey test (p=0.05). Nodule dry mass reduced by 57.2% after dicamba application in the base fertilization. However, the foliar nitrogen content increased from 41.72 to 45.52 g kg-1 on dicamba presence. As for the percentage of mycorrhizal colonization, the application of dicamba resulted in a reduction of 62.1%. However, there was no significant difference regarding the foliar phosphorus content, which presented an average of approximately 2.57 g kg^{-1}. The chlorophyll index (SPAD) after 48 hours of dicamba application decreased by 6.46% on complete nutritional condition. At 7 DAA the SPAD returned to normal levels (34.6) in all treatments, indicating the transient effect of the herbicide on the plant. No alteration in the maximum quantum yield (Fv/Fm) occurred in any period evaluated. It suggests that although the chlorophyll index reduced 48 hours after dicamba application, the photosynthetic apparatus of the plants remained intact. In addition, the variables related to the growth and development of the plants did not suffer significant impacts. Finally, although the relationship with microorganisms is negatively affected, there was no short-term damage to the plant itself, but it is necessary to evaluate such exposure over consecutive years.

Assessing Organic Mulch and Herbicide Combinations on Weed Control in Christmas Tree Production. Greta Gallina*[1], Debalina Saha[2], Eric L. Patterson[1], Bert Cregg[1]; [1]Michigan State University, East Lansing, MI, [2]Michigan State University, Apopka, FL (60)

Weed competition directly relates to the rate of Christmas tree growth during the second and third years of establishment. Weeds must be properly managed during this time to allow for good tree growth. The objectives of this experiment were to evaluate the weed control efficacy of organic mulch and herbicide combinations and to determine their phytotoxic effects on four different species of Christmas trees during this crucial establishment stage. The experiment was conducted at four Christmas tree farms, located in various regions of Michigan. The four species of Christmas trees used were Fraser fir [*Abies fraseri*(Pursh) Poir], blue spruce (*Picea pungens* Engelm.), white pine (*Pinus strobus* L.), and Scotch pine (*Pinus sylvestris* L.) during their establishment stage. Before treatments were applied the initial plant height and two widths of each tree as well as the dominant weed species in each field were recorded. The organic mulch applied was shredded cypress. Herbicides included clopyralid, oxyfluorfen, and glyphosate which were either applied alone, in combinations with each other, or in combinations with the organic mulch. Control was included which had no herbicide or mulch. There was total twelve treatments applied per field, with 4 replication each, they were in complete randomized block design. The mulch was applied at a depth of 5cm and diameter of 30cm. Liquid formulations of oxyfluorfen, glyphosate, and clopyralid were applied at their highest labeled rates of 4.6 LHa^{-1}, 1.9 L Ha^{-1}, 0.58 L Ha^{-1}, respectively. All herbicides and their combinations were applied uniformly with a CO_2 backpack sprayer calibrated at 252.55 LHa^{-1} output at 206.843 kpa pressure. Data collection included visual estimation of weed control at 30, 60, and 90 days after treatment (DAT) using a scale of 0% (no control) to 100% (complete control or total death). Visual estimation of the phytotoxic effects of the treatments to the Christmas trees were also recorded at, 30, 60, and 90 DAT at a scale of 0% (no plant injury) to 100% (complete death). Final growth indices of all trees were recorded at the end of the experiment. At 90 DAT, results showed that mulch combined with herbicide combinations can provide 70-100% weed control in all cases. However, clopyralid showed 26% and clopyralid + oxyfluorfen + glyphosate combination provided only 19% weed control in the field where the dominant weed species was common ragweed (*Ambrosia artemisiifolia* L.). Combinations of mulch + clopyralid + glyphosate and clopyralid + oxyfluorfen + glyphosate showed reduced growth and phytotoxic effect on blue spruce and Fraser fir, respectively. Whereas combinations of clopyralid + oxyfluorfen + glyphosate and mulch + clopyralid + glyphosate caused injury to scotch pine variety of Christmas tree.

Weed Seed Dispersal Via Overhead Irrigation in Container Nurseries. Alisha O. Ray*[1], Joe C. Neal[1], Anthony LeBude[2], James Altland[3], Chris Harlow[1]; [1]North Carolina State University, Raleigh, NC, [2]North Carolina State University, Mills River, NC, [3]USDA- ARS, Wooster, OH (61)

In the Southeastern U.S., nursery crop producers use open ponds of captured water for irrigating container-grown plants, often without filtration. Many growers perceive irrigation water as a significant source of weed seeds, but there has been little research on this subject. In the present study we evaluated irrigation pond water as a source of weed seed contamination in container nurseries. The presence and diversity of viable weed seeds in irrigation water samples from six commercial container nurseries in central and eastern NC was documented in autumn, spring, and mid-summer. Irrigation pond water was sampled using a custom-fabricated filtration system. Six 20K-gal samples were filtered at each location for each season. Irrigation filtrates were collected in 355 µm-mesh sieves. Filtrate samples were spread onto the surface of a peat/bark/perlite substrate in flats and placed in a covered hoop house at the Horticulture Field Lab in Raleigh, NC. Seedling emergence was counted every 7 days for 12 weeks. Seedlings were identified to species and removed after counting. Unknown species were transplanted and grown to maturity for identification. Weed species prevalence was ranked by average number of seedling emergence per 20K-gal sample for each season. Irrigation samples from all locations and seasons contained viable weed seeds. Location was not significant, except for one location in the summer season sampling which had greater numbers of weed seeds compared to the five other locations. Significant differences between seasons were observed, with average weed seed emergence averaged across locations of 16.4, 9.6, and 10.3 seeds per 20K gallons in autumn, spring and summer, respectively. There were 35 different species present in autumn, 30 in spring, and 42 in summer. The most prevalent weed species in both autumn and summer samples was *Eclipta prostrata*. *Epilobium ciliatum* was most prevalent in spring samples. Other common nursery weed species that were present in irrigation filtrates included *Euphorbia maculata*, *Cyperus iria,* and *Rorippa palustris*. Although many species collected in irrigation samples were not commonly observed in container crops at these sites, they were present in vegetation surrounding the ponds and non-production areas of the nursery sites. Many species present in samples coincided with the season in which those weeds were mature and actively shedding seeds in the nursery. However, *E. prostrata,* emerged in all seasons, even when no mature plants were present at the nurseries. This confirms our prior research documenting that weed seeds can remain viable in irrigation ponds for at least one year. Irrigation could be a source of seed spread in container nurseries for both new and endemic weed species. However, the contribution of irrigation-distributed seeds to overall weed seed spread in nurseries is, as yet, unclear.

Peppermint (*Mentha* × *piperita*) Response to Mesotrione and *S*-Metolachlor Applied Post-Harvest. Jeanine Arana*, Stephen L. Meyers; Purdue University, West Lafayette, IN (62)

Amaranthus species are the most troublesome weeds in Indiana peppermint production and can dramatically reduce the yield of mint hay and oil. Additionally, weeds contaminate mint hay and oil, reducing its quality and value. Unfortunately, current herbicide options for Indiana mint farmers are limited, and no Group 15 or 27 herbicides are registered for use in the state. Mesotrione (Group 27) and *S*-metolachlor (Group 15) herbicides can effectively control *Amaranthus* species. To better understand the impact of mesotrione and *S*-metolachlor on peppermint tolerance and yield, we determined the dose-response curves of peppermint to both herbicides. Two dose-response greenhouse trials for each herbicide were conducted at the Purdue University Horticulture Greenhouses, West Lafayette, IN, in 2021. The experimental unit consisted of a 20 cm polyethylene pot into which four shoot tip cuttings were planted. Treatments included five rates: 0, 105, 210, 420, and 840 g ha^{-1} for mesotrione and 0, 1000, 2000, 3000, and 4000 g ai ha^{-1} for *S*-metolachlor. Treatments were applied one day after a simulated harvest for the mesotrione and on the same day of the harvest for the *S*-metolachlor trials. Visual crop injury was rated on a scale of 0% (no injury) to 100% (crop death). Height measurements of five shoots in each pot were recorded 14, 28, 42, and 52 (days after treatment) DAT for the mesotrione, and 14, 28, and 42 DAT for the *S*-metolachlor trials. Aboveground biomass samples were harvested 52 DAT for the mesotrione and 42 DAT for the *S*-metolachlor trials. Samples were dried at 60°C for three days. Data were converted to a percent reduction of the untreated control average and then subjected to ANOVA. Significant variables were subjected to non-linear regression analysis. Peppermint's response to mesotrione was unacceptable. Even at 52 DAT, as the mesotrione rate increased from 105 to 840 g ha^{-1}, peppermint height was reduced 12 to 79%, visual crop injury (bleaching, stunting, and leaf distortion) increased from 4 to 84%, and dry weight was reduced 42 to 98%. In contrast, *S*-metolachlor was safer. At 14 DAT, as *S*-metolachlor rates increased from 1000 to 4000 g ha^{-1}, peppermint height was reduced 29 to 67%, and visual crop injury (necrosis, stunting, and leaf distortion) increased from 35 to 70%. At 28 DAT, the same rates of *S*-metolachlor reduced height 8 to 38% and increased visual crop injury from 1 to 40%. At 42 DAT, plants had recovered, and dry weight was not significantly reduced at any of the rates applied. Based on these results, mesotrione is not safe at the rates used in this study due to severe peppermint injury and dry weight reduction, but applying *S*-metolachlor post-harvest at 1000 g ha^{-1} may be a safe and efficacious method of *Amaranthus* control in peppermint.

Electrical Weed Control as a Tool for Integrated Weed Management in Carrot and Green Bean Production. Erin E. Burns, Zachary Hayden, Christopher G. Galbraith*, Sushila Chaudhari; Michigan State University, East Lansing, MI (63)

Electrical weeding (EW) is an emerging practice that applies high-voltage electricity to weeds through the use of tractor-mounted equipment. While this novel tool is restricted by its low selectivity, it appears well-suited for control of escaped and herbicide resistant weeds in numerous cropping systems. Field trials were conducted in summer 2021 to determine (1) efficacy of weed control and (2) level of crop injury and impact on yield caused by EW. Non-chemical control methods (hand weeding and varying number of EW passes) were tested in conventional carrots and organic green beans, as well as in conjunction with different herbicide treatments for the carrot trial. Two EW passes applied in succession appears optimal in terms of balancing control and operating costs in carrot, as the treatment provided similar control to hand weeding. In green beans, hand weeding provided the best control, followed by two EW passes in succession. EW caused no damage to internal root structure in carrot and minimal foliar injury in both crops. None of the non-chemical weed control methods led to a significant difference in carrot root length or carrot/green bean yield when considered against observed variation in weed pressure across treatments. This indicates that the primary benefit of EW for late season control may lie more in its potential for reducing weed seed bank replenishment by eliminating weeds prior to seed maturation/dispersal, thus increasing yield potential for the coming years. Further weed seed viability testing will explore these possibilities directly, as part of an overall research program exploring agroecosystem responses to EW. While not without its limitations, electrical weeding appears promising in its capacity to improve integrated weed management in modern vegetable production.

Herbicide Tolerance Evaluation of Early Post Emergence Treatments on Texas Native Grasses Under Greenhouse Conditions. Wyatt J. Stutzman*, Zachary S. Howard, Matthew Matocha, Scott A. Nolte; Texas A&M University, College Station, TX (65)

Pasture renovation and re-establishment to native forage species is a desirable practice in Texas (Godefroid et al, 2010); however, competition with weeds makes establishing these forages challenging due to the lack of herbicide options (Randall, 2017). Therefore, eight species of common pasture grasses native to Texas were evaluated for tolerance to six different herbicides applied at typical 1x use rates. The treatments were made at 7-10 days after emergence and evaluated weekly for 30 days followed with bi-weekly ratings until 60 days after application. Symptomology evaluations included visual estimates of necrosis, chlorosis, bleaching, and epinasty with additional ratings of plant height, quantity of plants left alive and a final dry biomass. The trial was conducted under greenhouse conditions with temperatures ranging from 55 to 95 degrees Fahrenheit in a 6x8 factorial design with untreated checks of each species and 4 replications. The study was also repeated in time. The eight species evaluated were Blue grama (*Bouteloua gracilis*), Sideoats grama (*Bouteloua curtipendula*), Hooded windmillgrass (*Chloris cucullata*), Sand lovegrass (*Eragrostis trichodes*), Green Sprangletop (*Leptochloa dubia*), Buffalo grass (*Bouteloua dactyloides*), Galleta grass (*Pleuraphis jamesii*), and Little bluestem (*Schizachyrium scoparium*). The six treatments consisted of Anthem Flex (carfentrazone-ethyl & pyroxasulfone) 0.003 kg a.i./ha and 0.045 kg a.i./ha respectively, Beyond (imazamox) 0.045 kg a.i./ha, Derigo (foramsulfuron, iodosulfuron-methyl-sodium & thiencarbazone-methyl) 0.050 kg a.i./ha, 0.005 kg a.i./ha, and 0.021 kg a.i./ha respectively, Duracor (florpyrauxifen-benzyl & aminopyralid) 0.008 kg a.i./ha and 0.093 kg a.i./ha respectively, Talinor (bromoxynil & bicyclopyrone) 0.205 kg a.i./ha and0.049 kg a.i./ha respectively, and Telar XP (chlorsulfuron) 0.042 kg a.i./ha. Among the six herbicide treatments, Beyond, Duracor and Talinor caused the least visible symptomology and biomass reduction. These three herbicide treatments also resulted in the greatest survivability across the native species with more plants remaining alive throughout the trial. The remaining treatments consistently caused significant differences in injury, height and biomass reduction, and reduced quantity of plants alive. Results of this study were used to select herbicide candidates for evaluation in field-based, native-species tolerance studies.

The Effect of Novel Adjuvants on Glyphosate Activity in Common Lambsquarters. Isabel Schlegel Werle*[1], Gustavo Bessa[1], Matheus Machado Noguera[1], Srikanth Kumar Karaikal[1], Jeremie Kouame[1], Johan Coetzee[2], Nilda Roma-Burgos[1]; [1]University of Arkansas, Fayetteville, AR, [2]ORO AGRI-Rovensa, Fresno, CA (66)

Adjuvants can improve the performance of herbicides by increasing absorption, minimizing herbicide leaching, and reducing rainfastness. In this study we investigated the use of adjuvants with glyphosate with respect to absorption and translocation in common lambsquarters (*Chenopodium album* L.). Differential absorption and translocation of ^{14}C-glyphosate was evaluated in a two-factor factorial laboratory study with seven adjuvants and three harvest times. Common lambsquarters plants (15- to 20-cm tall) were sprayed with glyphosate (Roundup Weathermax®) at 772 g ae ha^{-1} in combination with one of the following adjuvants at 0.25% v v^{-1}: OR-009-E, OR-494-A, OR-295-A, OR-278-F, X-VRT, X-LOO, or X-AQE. Plants were then spiked with 130,000 disintegrations per minute (DPM) of ^{14}C-glyphosate. The radiolabeled glyphosate was applied in four, 1-uL droplets, two on each side of the lamina of the youngest, fully expanded leaf. Spotted leaves were harvested at 30 min, 4 h, and 12 h after application (HAP) and rinsed for about 10 s in a series of three vials containing 5-ml 5% methanol solution. The rinsates were combined in one vial, a 5-ml aliquot was added with 10 mL scintillation cocktail, and radioactivity was quantified using a liquid scintillation spectrometer. Absorption and translocation were calculated as percentage of the total ^{14}C-glyphosate recovered and the total ^{14}C-glyphosate absorbed, respectively. Treatments were arranged in a completely randomized design with six replications. Data were subjected to ANOVA and means were compared using Student's t test (a=0.05). Adjuvant-herbicide interactions increased ^{14}C-glyphosate absorption. The adjuvants X-VRT, X-AQE, and OR-278-F enhanced ^{14}C-glyphosate absorption at 4 and 12 HAP. ^{14}C-glyphosate absorption increased over time, from less than 10% at 30 min to 80% at 12 HAP. There were no differences in ^{14}C-glyphosate translocation between adjuvants within 12 h from application. Nearly 80% of the ^{14}C-glyphosate applied remained in the treated leaf at 12 HAP. Some novel adjuvants can increase glyphosate absorption, thus, enhancing its efficacy. However, there is minimal (or slow) translocation of glyphosate in lambsquarters until 12 HAP. Translocation at 24-, 48-, and 96 h need to be investigated.

An Integrated Multi-Omics Approach to Capture Stress-Induced Cellular Physiology in Plants: A Case Study Using Glyphosate-Resistance in Palmer Amaranth (*Amaranthus palmeri*). Pawanjit Kauur Sandhu*[1], Elizabeth Leonard[1], Vijay Nandula[2], Nishanth Tharayil[1]; [1]Clemson University, Clemson, SC, [2]USDA, Kansas City, MO (68)

Evolution of resistance to herbicides in weed biotypes is a major threat to global agricultural production systems. To date, 55 weed species have developed resistance against glyphosate, the most widely used herbicide worldwide. Palmer amaranth (*Amaranthus palmeri*) is a dominant glyphosate-resistant weed that causes more than 50% yield loss in row crop production systems of the southeastern US. The primary mechanism of resistance in Palmer amaranth is gene amplification of the target enzyme, 5-Enolpyruvylshikimate-3-phosphate synthase (EPSPS). However, the glyphosate-induced cellular physiology of glyphosate-resistant (GR) and -susceptible (GS) biotypes remains obscure, especially since the partial blockage of the shikimate pathway is evident in GR biotypes immediately after glyphosate application. Here, we integrated transcriptomic, proteomic, and metabolomic approaches to elucidate the glyphosate-induced stress perturbations in GR and GS-biotypes of Palmer amaranth.RNAseq transcriptomics, shot-gun proteomics, and untargeted metabolomics analysis of leaf tissues twenty-four hours after glyphosate treatment resulted in 30371 transcripts, 5606 master proteins, 80 primary, and 525 secondary metabolites, respectively. Correlation analysis of transcripts and the corresponding proteins revealed a positive association ($r = 0.53$) between the two in glyphosate-treated tissues of both biotypes. Functional analysis of differentially expressed transcripts and proteins showed upregulation of ABA-activated signaling pathway, signaling receptor activity, protein phosphatase inhibitor activity (GO terms), and glutathione metabolism (KEGG pathway) across biotypes at both transcript and protein levels. Further, the effect of glyphosate was more significant on GS-biotype than GR-biotype on transcripts (3349 vs 1028), proteins (226 vs 71) and primary metabolites (19 vs 6). Interestingly, the secondary metabolome was more perturbed in GR-biotype (120 vs 68). Glyphosate-induced reduction of identified phenylpropanoids was similar across the biotypes. However, there was a significant decrease in the abundance of triterpenoids in the GR-biotype that was not observed in the GS-biotype. Overall, our results show that the glyphosate-induced perturbations are pervasive across multiple levels of cellular regulation and glyphosate resistance in Palmer amaranth did not provide immunity against these perturbations. This study lays the groundwork for integrating multiple omics techniques to elucidate the cellular physiology of herbicide perturbations.

Impact of Management Practices on the Evolution of Herbicide- Resistant Waterhemp (*Amaranthus tuberculatus*) in Iowa. Ryan Hamberg*[1], Prashant Jha[1], Micheal D. Owen[1], Chandrashekar Aradhya[2], Avery J. Bennett[1], Alexis L. Meadows[1], Austin H. Schleich[1], Ramawatar Yadav[1]; [1]Iowa State University, Ames, IA, [2]Bayer Crop Science, Chesterfield, MO (69)

Multiple herbicide-resistant (MHR) waterhemp is an increasing concern for corn and soybean growers across the Midwest. Early detection and rapid response would be needed to prevent further spread of MHR waterhemp. It is critical to understand how management practices influence changes in herbicide resistance dynamics over time. Seed samples of 200 waterhemp populations were collected from georeferenced corn and soybean fields in Iowa in the fall of 2019. These populations were previously screened in a random field survey conducted in 2013. The first objective was to determine the temporal (2019 vs. 2013) changes in resistance frequency (% of populations) and distribution of MHR waterhemp in Iowa corn and soybean fields. The second objective was to quantify how cropping patterns contributed to changes in resistance frequency over the 6-year period. Two hundred waterhemp populations were screened with eight different herbicide sites of action in a greenhouse at the Iowa State University, Ames, IA. These included inhibitors of ALS (imazethapyr), PS II (atrazine), PPO (lactofen), HPPD (mesotrione), and EPSPS (glyphosate), Glufosinate, 2,4-D, and dicamba were also included for the 2019 survey. The first five herbicides were tested at 1X (field-use rate) and 4X rates similar to the 2013 survey, while glufosinate, 2,4-D, and dicamba were tested at 1/2X and 1X rates. For each population and herbicide dose, 30 plants (10 plants per replication; 3 replications) were sprayed using a stationery cabinet spray chamber (8001 even flat-fan nozzle tip calibrated to deliver 132 L ha^{-1}). Experiments were conducted in a randomized complete block design and repeated. Percent visible injury (0 to 100%) and a binomial response (dead/alive) of plant survival was recorded 28 days after application. A population was considered resistant if >50% survived either rate. The cropping history data (2013-2019) were retrieved from the USDA NAAS CDL website. The frequency of resistance to the 4X rate of imazethapyr was 95% in 2019 vs. 85% in 2013. A higher proportion of the populations were resistant to glyphosate (4X rate) in 2019 (62%) vs. 2013 (25%). Atrazine resistance (4X rate) increased from 55% in 2013 to 68% of the populations in 2019. For lactofen and mesotrione (4X rates), none of the populations were resistant in 2013 but increased to 3% in 2019. Seven percent of the populations collected in 2019 survived the field-use rate of 2,4-D, with no survivors from dicamba or glufosinate. A three-way resistance was exhibited by only 13% of the populations in 2013 vs. 58% in 2019. Five-way MHR populations increased from none in 2013 to 5% in 2019. A binomial, logit: link function in *R* assessed whether cropping history influenced the resistance development in waterhemp populations over the 6-year period. There was a strong relationship ($P < .0001$) between HPPD-resistant waterhemp and corn-corn vs. corn-soybean rotations. In conclusion, MHR waterhemp populations are increasing in frequency and widely distributed across corn and soybean fields in Iowa. This warrants the need for the inclusion of non-chemical strategies (cover crops, reduced row spacing, and harvest weed seed control).

Preliminary Investigation of Biological Nitrification Inhibition (BNI) Potential in Johnsongrass (*Sorghum halepense*). Eeshita Ghosh*, Nithya Rajan, Dinesh Phuyal, Muthukumar V. Bagavathiannan, Nithya K. Subramanian; Texas A&M University, College Station, TX (70)

Nitrogen is one of the most limiting plant nutrients, which is taken up by plants in the form of ammonia (NH_3) or nitrate (NO_3^-). In the soil, ammonia is actively converted to nitrate by various microorganisms. This process, known as nitrification, affects soil nitrogen retention because nitrate is less stable in the soil environment and can be rapidly lost through denitrification or leaching. These loss processes greatly reduce nitrogen availability for plant growth. Some plant species, such as *Brachiaria humidicola* (signalgrass), have evolved mechanisms to inhibit nitrification by secreting root exudates; this phenomenon is known as Biological Nitrification Inhibition (BNI). BNI allows a plant to retain greater amounts of nitrogen in the form of ammonia, which in turn improves its growth. It has been established that sorgoleone secreted by *Sorghum bicolor* (sorghum) has BNI potential. We hypothesize that the dominance and invasiveness of *Sorghum halepense* (johnsongrass), a weedy relative of cultivated sorghum, could be attributed in part to its BNI properties. However, little has been investigated in this regard. Here, we conducted a field survey in the Southeast Texas region to determine the extent of nitrification inhibition in naturally occurring *S. halepense* populations under cultivated field as well as roadside conditions. A total of 5 random locations were surveyed in the region, with a pair of field and nearby roadside populations (within 1 km of each other) in each location, making a total of 10 survey sites. In each site, *S. halepense* rhizosphere soil was collected at a depth of 15 cm; soil samples were also collected in areas outside of *S. halepense* infestation for comparison. A sub-sample was analyzed using colorimetric assay for ammonium and nitrate contents and the ratio of ammoniacal nitrogen out of the total available nitrogen was calculated. Preliminary results indicate that *S. halepense* has the ability to inhibit nitrification as it can retain a high amount of ammonium (greater than 60% of total N) in rhizosphere, but the degree of nitrification inhibition varied across the locations. In general, field *S. halepense* populations had 20-30% more ammonia in their rhizosphere than roadside populations, compared to their respective standards (i.e. in areas outside of *S. halepense* infestation within each site). Further, the amount of ammonium retained by roadside *S. halepense* populations was up to 40% greater than that of field populations in some locations. Results suggest that environmental factors and soil characteristics influence nitrification inhibition property of *S. halepense*. More investigations are currently ongoing to understand the influence of *S. halepense* genotype and soil characteristics on the extent of nitrification inhibition. Further, rhizosphere microbial analysis will be conducted to determine whether this property is due to the inhibition of nitrifying bacteria (i.e. BNI).

Potential of Using Wildland Weeds for Honeybee Health in Puerto Rico. Andrés Curcio Santiago*[1], Wilfredo Robles[2], Fernando Gallardo[3], Alejandro Segarra[4], Aristides Armstrong[5]; [1]University of Puerto Rico, Mayagüez, Trujillo Alto, PR, [2]University of Puerto Rico, Mayagüez, Corozal, PR, [3]University of Puerto Rico, Mayagüez, Adjuntas, PR, [4]University of Puerto Rico, Mayagüez, Lajas, PR, [5]University of Puerto Rico, Mayagüez, Mayagüez, PR (71)

Coffee and citrus production relies on pollinators like the honeybee. In Puerto Rico, both crops are mainly grown within the central mountainous region where many wildland weeds species may serve as melliferous plants for supporting honeybee health. Often the lack of information at hand by farmers lead to the use of herbicides for controlling all weed species despite considering their low impact on the crop or high potential as a melliferous plant species. Therefore, field surveys were conducted in May 2021 at the Agricultural Experiment Station of Adjuntas (EEA) to identify the frequency of occurrence of plant species and their spatial distribution in relation to the established apiary of this location. A handheld GPS unit was used to navigate a grid of survey points 100 meters apart that extends uniformly over this research farm. During the survey, pollen grains were collected from the established beehives at the apiary then sorted according to colors and mounted on microscope slides for further identification. As a result, a total of 25 families represented by 53 species of wildland weeds were identified. The most common species observed were *Mikania micanthra* as its frequency of occurrence was 44% followed by *Mimosa pudica* and *Sporobolus indicus* with 11%. The plant families Asteraceae, Fabaceae and Poaceae are represented by the aforementioned species. On the other hand, the most common pollen type found at the beehives was tricolporate which is a commonly found on plant species from the Asteraceae and Fabaceae family. Other pollen types found belonged to the Arecaceae and Poaceae taxa. These results may indicate that wildland weed species from the Asteraceae, Fabaceae and Poaceae family might help support honeybee health during the late spring.

Weed and Crop Emergence Through Chaff Lines as Influenced by Crop Yield. Matthew P. Spoth*[1], Michael L. Flessner[1], Lauren M. Lazaro[2], Travis Legleiter[3], Kevin W. Bamber[1], Wykle C. Greene[1], Eli C. Russell[1], Cynthia Sias[1], Vipin Kumar[4], Vijay Singh[4]; [1]Virginia Tech, Blacksburg, VA, [2]Louisiana State University, Baton Rouge, LA, [3]University of Kentucky, Princeton, KY, [4]Virginia Tech, Painter, VA (73)

Harvest weed seed control methods manage weed seeds during crop harvest operations. Chaff lining is a form of harvest weed seed control in which the chaff fraction of harvest residues and weed seeds therein are concentrated into a narrow line behind the combine. Chaff deposition into the line increases in response to greater crop yield. The objective of this research was to evaluate how varying crop yield and therefore amounts of chaff deposition affect weed and subsequent crop emergence within chaff lines. Weed species included Palmer amaranth (PA) (Amaranthus palmeri S.) and common ragweed (CR) (Ambrosia artemisiifolia L.) subject to soybean chaff lining and wild mustard (Sinapis arvensis L.) and Italian ryegrass (Lolium perenne L. ssp. multiflorum (Lam.) Husnot) in wheat chaff lining, with each evaluated in separate experiments. Additionally, cereal rye as a cover crop following soybean harvest and soybean after wheat, representative of a double crop production system, were evaluated in terms of above ground biomass and emergence, respectively. Chaff lines were created to mimic a range of soybean and wheat yields with equal weed seed additions or planting densities. Experimental design followed randomized complete block in field and greenhouse studies. Data analyses conducted using JMP included standard least squares regressions. Our results indicate chaff alters the environment to be unfavorable for both weed seed and crop emergence. In wheat chaff lining, WM and IR emergence decreased by 37 – 57 plants per 1 m of chaff line with every 1000 kg increase in wheat yield. Likewise, CR and PA emergence through soybean chaff decreased by 33 – 101 plants per 1 m of chaff line. In greenhouse trials, chaff amount was a significant ($p<0.001$) predictor of all weed species emergence and biomass. For each 1 kg ha^{-1} increase in soybean and wheat yield, weed suppression ranged from 0.6 – 8.0 plants m^{-2} with R^2 values ranging from 0.3 – 0.73. Although soybean emergence was overall greater in the greenhouse, emergence decreased 9.5 – 13.5 plants ha^{-1} per kg increase of wheat yield regardless of the setting. Cereal rye was less affected by soybean chaff amount, with only a 0.002 kg ha^{-1} in the greenhouse and 0.09 kg ha^{-1} in the field biomass reduction per kg increase in yield. This research shows increasing rates of chaff being placed during chaff lining operations reduces weed emergence within chaff lines, although a similar result can be had on crops. These initial results are very promising and indicate the potential of chaff lining to improve weed management and combat herbicide resistance.

Unmanned Aerial System-Based Site-specific Weed Management in Soybean. Vipin Kumar*, Vijay Singh, Dhiraj Srivastava; Virginia Tech, Painter, VA (74)

Herbicide resistant weeds and weed escapes are serious issue in agricultural production as they lead to increased weed seed bank and promote weed infestations in following years. In such scenarios, semi-automatic Unmanned Aerial System-based herbicide application technology has shown the potential to control these weeds based on geo-coordinates of weed presence. This technology is not only economical but can save 80-90% of the pesticide usage leading to reduced chemical load on agro-ecosystem. A study was conducted in 2021 at Painter, VA to evaluate site-specific spray applications with UAS (Precision Vision 35PX) to control weeds in soybean field. Twenty weed spots were selected at random. Additional pots and trays filled with Palmer amaranth (*Amaranthus palmeri* S. Watson) and large crabgrass (*Digitaria sanguinalis* (L.) Scop.) seedlings of two different stages were kept at those random spots. Trays had about 50 seedlings (5-10 cm tall) of each weed and three pots of 20-25 cm tall Palmer amaranth plants. These spots were marked and mapped with aerial imagery using DJI M300. Images were orthomosaiced using Pix4Dmapper. Geo-coordinates of spots were extracted and ESRI shapefile was generated, and used as an input data for UAS-based herbicide application plan. UAS sprayed each spot automatically for 1-second without pilot intervention. Weeds were treated with recommended rate of Liberty (glufosinate) herbicide, applied at 2.1 m altitude and volume rate of 140 L ha^{-1}. Studies were repeated over time and space with a gap of one month. UAS sprayed herbicide with a deviation/ displacement ranged from 0 to 1-m. Fifty percent of the spots were sprayed without any displacement, 15% with 0.25-m, 15% with 0.5-m, and 20% of spots with 1-m displacement. Weed control efficiency in field area and for seedlings in trays were statistically similar at 0 and 0.25-m displacement, resulting in spraying 65% of the spots within 25-cm of target radius. The overall weed control efficiency in field was 94% (considering five major weed species) and control of Palmer amaranth and large crabgrass seedlings was more than 95% in 65% of the targeted spots. In pot study, Palmer amaranth was controlled >90% in 80% of the targeted spots. Large crabgrass control was significantly lower (80-90%) at 0.5 and 1-m displacement compared with Palmer amaranth. Results have indicated that current UAS technology can accurately spray within 1-m of target, providing 70-100% control of weeds. Spot spray application at lower wind- and UAS-speed and is expected to increase the accuracy.

Integration of Unmanned Aerial System and Machine Learning for Weed Mapping Operations. Dhiraj Srivastava*[1], Vijay Singh[1], Michael L. Flessner[2], John McGee[2], Kevin Kochersberger[2]; [1]Virginia Tech, Painter, VA, [2]Virginia Tech, Blacksburg, VA (75)

Weeds are among the most challenging pests in the crop production system and are often found in patches/spots throughout the field, causing significant yield losses. Integration of Unmanned Aerial System (UAS) and Machine Learning can help in site-specific weed management by creating weed signature library. The robust identification of weeds in the large agricultural field can be done by combining image acquisition by UAS under all weather conditions and further processing by machine learning techniques. Powerful machine learning algorithms can be trained on quality image data to build robust models to help manage weeds either though automatic weed removal by robotic systems or UAS-based herbicide spray applications. The focus of this research is to present a new architecture of machine learning to detect common ragweed (Ambrosia artemisiifolia) in soybean (Glycine max). Common ragweed is a troublesome weed species in soybean production system in the United States. This research was conducted in 2021 at Painter, VA, where UAS-based red, green, and blue (RGB) images were acquired at different growth stages of soybean and common ragweed, using DJI M-300 flown at an altitude of 12 meters. Images were orthomosaiced using Pix4D software. A set of pixels (500*500) from orthomosaiced images were extracted to feed classification models. VGG Image annotator (VIA) was used to annotate the image data forbuilding object detection models. Confusion matrix analysis was conducted to evaluate the performance of the model. Experimentally, we observed that our current model has high performing architecture to detect common ragweed in soybean. The model achieved a test accuracy >85%, with precision > 78% and recall > 96% for identifying common ragweed. The study results indicate that this model has the potential to be utilized for site-specific operations, leading to reduced herbicide usage, and ensuring sustainable crop production.

Impacts of Cover Cropping on Weed Dynamics in Eastern and Central Nebraska. Elizabeth Oys*, Andrea Basche, Katja Koehler-Cole; University of Nebraska-Lincoln, Lincoln, NE (76)

Nebraska leads the nation alongside Kansas with the total number of acres in no-till production, causing weed management to shift to herbicide dependence mainly. Over-reliance on herbicides can contribute to herbicide resistance evolution in many weed species, a problem that Nebraska currently faces. Shifting towards integrated weed management (IWM) practices like cover cropping alongside crop rotation diversifies weed management and can mitigate risks of weed developing herbicide resistance quickly. Nebraska cover crop (CC) acres increased nearly 50% from 2012 to 2017 and CCs can provide weed competition and suppression through a multitude of mechanisms. This study attempts to quantify CC impacts on weed dynamics through weed seedbank and in-season weed assessments at six on-farm and research station sites. Results show that while total seedbank density was not significantly impacted by CC, the proportion of pigweeds increased in the seedbank at some sites. However, in-season total aboveground weed density did not reflect the seedbank increase in pigweeds at any site and in some cases, decreased. Furthermore, total weed biomass was reduced in CC at all sites, ranging from 15% to 98% reductions depending on site and sampling time (after crop emergence or 3+ weeks after POST). The results of this study reveal the impacts of cover crops on weed seedbanks while supporting CCs as a potential in-season IWM tool.

PhD Student Poster Contest

The Powerful Pigweed: A Tennessee Auxin Resistance Story. Delaney C. Foster*[1], Larry Steckel[1], Peter A. Dotray[2]; [1]University of Tennessee, Jackson, TN, [2]Texas Tech University and Texas A&M University, Lubbock, TX (77)

The prevalence of Palmer amaranth (Amaranthus palmeri S. Wats.) escapes in auxin-based cropping systems increased in Tennessee in 2019 and 2020.In many cases, dicamba or 2,4-D was applied timely to small (<10cm) Palmer amaranth. Resistance to dicamba and 2,4-D was confirmed in greenhouse studies conducted at Texas Tech University in 2020. In 2021, field experiments were conducted at the West TN AgResearch and Education Center and two growers' fields in Madison and Lauderdale counties where reports of Palmer amaranth escapes in previous years were prevalent to determine the level of resistance of these populations to dicamba and 2,4-D. In an attempt to determine the resistance mechanism, malathion insecticide (a cytochrome p-450 inhibitor) was investigates to examine if resistance could be due to enhanced metabolism of the herbicides. Experiments were also conducted to determine the best herbicide programs to control resistant Palmer amaranth populations. Results indicate that in the field, only 40-60% of Palmer amaranth <10 cm tall were controlled using 0.56 kg dicamba ha-1 and 45-65% were controlled with 1.12 kg 2,4-D ha-1. Malathion did not increase control with dicamba, regardless of application timing; the tank mix of malathion plus 2,4-D increased control compared with 2,4-D alone on <10 cm Palmer amaranth. This result might indicate metabolic resistance is in part causing the loss of control. Results on management suggest that the best option for growers will be sequential applications of dicamba or 2,4-D with glufosinate 7-10 days apart with no preference on order of herbicides applied.

Evaluation of One, Two, and Three-Way Preemergence Herbicide Combinations in Soybean. Zachary R. Treadway*, Jenny L. Dudak, Todd A. Baughman; Oklahoma State University, Ardmore, OK (78)

Evaluation of One, Two, and Three-Way Preemergence Herbicide Combinations in Soybean. Z.R. Treadway*, J.L. Dudak, T.A. Baughman; Oklahoma State University, Ardmore, OK Herbicide resistance is an ever-growing and complex issue for soybean producers. Confirmed resistance to acetolactate synthase (ALS), glyphosate, and protoporphyrinogen oxidase inhibiting (PPO) herbicides along with reports of glufosinate and auxin resistance proves to be quite problematic. Resistant weeds such as Palmer amaranth (*Amaranthus palmeri* S. Watson) can cause yield losses of over 45% when left uncontrolled. Previous research has shown an increase in weed control when applying a PRE residual herbicide combination with multiple modes of action. Experiments were conducted in 2020 and 2021 to evaluate four modes of action for PRE residual weed control in dicamba-tolerant soybean. Treatments included chloransulam-methyl (36 g ai ha^{-1}), metribuzin (417 g ai ha^{-1}), pyroxasulfone (95 g ai ha^{-1}), and sulfentrazone (163 g ai ha^{-1}). Herbicides were applied alone, as well as in two and three way combinations. All treatments were applied PRE. Treatments were followed by a POST application of dicamba (567 g ae ha^{-1}) + glyphosate (329 g ae ha^{-1}). Soybean visual injury never exceeded 10% at any point in the growing season. Palmer amaranth control was at least 98%, 2 weeks after planting (WAP), with the three-way combination of metribuzin + pyroxasulfone + sulfentrazone at 3 of 4 site years. Similar levels of control were achieved with all other treatments, except chloransulam-methyl alone and in combination with pyroxasulfone + sulfentrazone. Palmer amaranth control, 4 WAP, was 98-100% at 3 of 4 site years with pyroxasulfone in two or three-way combination with chloransulam-methyl and metribuzin, as well as the three-way combination of chloransulam-methyl + metribuzin + sulfentrazone. Control, following the POST application, was at least 97% with all three-way combinations, as well as with the two-way combination of pyroxasulfone + metribuzin. Control of large crabgrass (*Digitaria sanguinalis* (L.) Scop.), 2 WAP, was at least 90% at 3 of 4 site years with all treatments that included metribuzin, except in the two-way combination with sulfentrazone. Control of large crabgrass, 4 WAP, was at least 97% with all two and three-way combinations at 3 of 4 site years; except for sulfentrazone in combination with either chloransulam-methyl or metribuzin, or chloransulam-methyl + pyroxasulfone. Following a POST application of dicamba + glyphosate, control of large crabgrass only reached 98% in any site year with metribuzin + pyroxasulfone tank-mixed together or combined with chloransulam-methyl or sulfentrazone. When compared to the untreated check, soybean yield increased with every treatment. Combinations containing pyroxasulfone were the only treatments to consistently yield higher than the trial average in every sight year. Adversely, chloransulam-methyl alone was the only treatment to yield equal to or below the trial average in every site year. This is most likely due to the prevalence of ALS-resistant Palmer amaranth in Oklahoma. These trials exhibited the need for PRE residual herbicide combinations with multiple modes of action. This practice not only improves weed control and crop yield; but also protects new POST technologies from the development of future resistant issues.

Interaction of Quizalofop, 2,4-D Choline, and Glufosinate for Control of Glyphosate/glufosinate-resistant Volunteer Corn in Corn Resistant to Aryloxyphenoxypropionates. Mandeep Singh*[1], John Lindquist[1], Stevan Knezevic[2], Suat Irmak[3], Vipan Kumar[4], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]Penn State University, State College, PA, [4]Kansas State University, Hays, KS (79)

Volunteer corn is a concern for Mid-western corn and soybean growers. Quizalofop, an acetyl coenzyme A carboxylase (ACCase)-inhibiting herbicide, can control glyphosate/glufosinate-resistant volunteer corn in corn resistant to aryloxyphenoxypropionates (Enlist™ corn). Growers need to use other herbicides for diverse weed control as quizalofop is ineffective for controlling broadleaf weeds. Antagonism often results when ACCase-inhibiting herbicides are mixed with 2,4-D or dicamba for grass weed control. The objectives of this study were i) to evaluate the efficacy of quizalofop applied alone or mixed with 2,4-D choline and/or glufosinate, and ii) to evaluate the effect of timing of herbicide application (V3 or V6 stage) on volunteer corn control, Enlist™ corn injury and yield. A field experiment was conducted in 2021 at South Central Ag Lab, Clay Center, NE. Glyphosate/glufosinate-resistant corn seeds harvested from the previous season were cross-planted at 50,000 seeds ha^{-1} to mimic volunteer corn. After 4 days, Enlist™ corn was planted at 87,500 seeds ha^{-1}. Quizalofop, 2,4-D choline, and glufosinate were applied alone and in mixtures at low and high labeled rates of 47 and 94, 808 and 1077, and 663 and 891 g ai or ae ha^{-1}, respectively. Quizalofop applied alone provided 99% control of volunteer corn 28 d after application. However, antagonism was observed when quizalofop was mixed with 2,4-D choline, specifically when corn volunteers were at V3 stage for the first 2 weeks after application. The observed antagonism in volunteer corn control doesn't reflect significantly in corn yield losses. Results of this study suggest that growers should be cautious to mix quizalofop with 2,4-D choline, and separate herbicide application may be needed for volunteer corn and broadleaf weed control.

Influence of Cover Crop on the Critical Period for Weed Control in Soybean. Annu Kumari*[1], Andrew Price[2], Nicholas Korres[3]; [1]Auburn University, Auburn, AL, [2]USDA- ARS, Auburn, AL, [3]University of Arkansas, Fayetteville, AR (80)

Soybean is the world's most widely grown leguminous crop and is an important source of protein and oil for food. However, weed control challenges limit yield potential and threaten conservation systems. Troublesome weeds like Palmer amaranth, sicklepod and morning glory were identified as a detriment to yield in soybean crop production. Cover crops have been increasingly adopted as an integrated pest management component, to suppress weeds and maintain soybean yield potential. A three-year field experiment was conducted to estimate the influence of a cereal rye cover crop and conservation tillage on critical period for weed control (CPWC) in soybean. The split plot design included main plots as conventional tillage (CVT) and conservation tillage following winter fallow (CT + WF) and conservation tillage following rye cover crop (CT + CC) whereas subplots were multiple durations of critical weed free period and timing. The results illustrated that weed biomass under CT + CC treatment was less than CVT + WF and CT + WF systems during most of growing period. Moreover, the CPWC was the shortest in 2018 and 2019 following a cover crop while in the 2020 conventional tillage had the shortest critical period. Averaged over the years, cover crop presence delayed the critical timing for weed removal (CTWR) by approximately 1.5 to 2 wk. than CT + WF treatments. In addition, CVT delayed CTWR about 1.1 to 2 wk. compared with CT + WF. The 5% threshold limit relative yield loss was not attained up to 1wk after planting (WAP) for CT + WF and 3 WAP for CVT in all years, while CT + CC reported 3.2 WAP in both 2019 and 2020, but 2.5 WAP in 2018. In conclusion, CT + WF should be avoided to reduce weed competition and subsequent yield loss of soybean.

Interaction of Mesotrione and Metribuzin for Soil-Residual Control of Giant Ragweed (*Ambrosia trifida*). Benjamin C. Westrich*[1], Bryan G. Young[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, Brookston, IN (81)

The HPPD inhibitor mesotrione has recently gained regulatory approval for application in appropriately traited soybean varieties prior to emergence. To increase overall weed control and reduce selection pressure for resistance, growers planting these soybean varieties may choose to apply mesotrione in combination with Photosystem II inhibitors. Synergistic interactions have been observed when these modes of action are applied together. However, the interaction between mesotrione and metribuzin (a photosystem II inhibitor) when applied as a mixture for soil-residual control of giant ragweed (*Ambrosia trifida*, L.) has not been evaluated. To study this interaction, giant ragweed seeds were cold-stratified in a 3:1 mixture of sand to soil for 2 to 3 months to alleviate dormancy, then planted in pots containing a sandy-loam field soil. Dose-response curves for each herbicide or herbicide mixture were generated by applying mesotrione and metribuzin immediately after planting at rates evenly spaced on a $\log_4$ scale from 4 to 1,024 and 8 to 2,048 g ai ha^{-1}, respectively, using a research track sprayer. Mixtures of these herbicides were applied according to a multi-ray fixed-ratio design of 1:1, 1:2, and 2:1 ratios of their relative potency. Each rate and control were replicated six times, and the experiment was conducted twice. A total of 3.3 cm of overhead irrigation designed to simulate rainfall was applied over the next 10 d to distribute the herbicide(s) throughout the soil profile, and sub-irrigation was used for the remainder of the experiment. After 14 d, the reduction in fresh weight was determined for each treated pot and compared with the nontreated control. Dose-response curves were generated using a three-parameter log logistic model and the *drc* package in R. Visual inspection of Isobolograms representing the ED50 values of each herbicide mixture indicated that the interaction of mesotrione and metribuzin in soil-residual applications was synergistic. The magnitude of synergy was precisely defined by interaction indices of 0.76, 0.78, and 0.51 for the 1:1, 1:2, and 2:1 mixture ratios, respectively. The upper 95% confidence limit of all interaction indices was less than 1, which supported our visual assessment of the Isobolograms. Overall, these results indicate that the application of a mixture of mesotrione and metribuzin is likely to be synergistic for soil-residual control of giant ragweed. However, the dynamics of this interaction may differ under field conditions, where the relative dose of each herbicide that is available for uptake and the position of those herbicides in the soil profile will vary throughout the growing season.

Rolled-crimped Cover Crop Effects on Weed Suppression and Organic No-till Planted Wheat (*Triticum aestivum*) Performance. Matthew R. Ryan[1], Sandra Wayman[1], Terry Rose[2], Christopher J. Pelzer[1], Uriel D. Menalled*[1]; [1]Cornell University, Ithaca, NY, [2]Southern Cross University, Lismore, Austria (82)

Cover crop mulches can be an important mechanism of weed suppression in organic no-till crop production. However, research is lacking on no-till planting organically managed winter wheat (*Triticum aestivum* L.) into rolled-crimped cover crops. An experiment was conducted at two sites in New York, USA, to test the effects of no-till planting winter wheat into five warm-season cover crops [buckwheat (*Fagopyrum esculentum* Moench), radish (*Raphanus sativus* L.), sorghum sudangrass [*Sorghum bicolor* (L.) Moench x *S. sudanense* (Piper) Stapf.], soybean [*Glycine max* (L.) Merr.], and sunn hemp (*Crotalaria juncea* L.)] that were planted in early-, mid-, and late-summer. Cover crops were terminated with a roller-crimper, and winter wheat was no-till planted into the cover crop residue and a tilled control in fall. Cover crop biomass, wheat seedling emergence, weed biomass, and wheat yield were quantified across all treatments. Cover crop and weed biomass at wheat planting varied by cover crop and planting date. Typically, the early-planted cover crops produced the most biomass and achieved the greatest amount of weed suppression. Despite increased weed suppression in high-biomass cover crop mulches, none of the mulches reduced wheat emergence compared to the tilled control. Likewise, except for the no-till wheat in the late-planted soybean mulch, yields in the no-till system were comparable to the tilled control. Thus, cover crop mulches can be used to suppress weeds with a low risk of reducing crop establishment and yield, making them an effective means for reducing tillage in Northeastern organic wheat production.

The Truth is in the Numbers: Can We Delay Herbicide Resistance Through an Integrated Approach? Taylor M. Randell*, Jenna C. Vance, Hannah E. Wright, A Stanley Culpepper; University of Georgia, Tifton, GA (83)

As herbicide resistance continues to evolve, the implementation of integrated weed management practices to reduce selection pressure is paramount. An experiment was conducted three times during 2020 and 2021 to quantify the reduction in selection pressure placed on Palmer amaranth (*Amaranthus palmeri*) by 2,4-D applied POST in tolerant cotton, through utilization of 1) cover crops, 2) preemergence (PRE) herbicides, 3) POST herbicide tank mixes, and 4) timely POST applications. Treatments were arranged in a split-plot design, with the whole plot representing the production system. Cotton was either planted into a conventionally tilled, bareground field, or strip tilled into a terminated, rolled rye cover crop. Herbicide treatment and application timing represented the split-plot, and included (1) PRE (acetochlor at 840 g ai ha^{-1} + fomesafen at 210 g ai ha^{-1}) fb 3 timely POST applications (glyphosate at 1,541 g ai ha^{-1} + 2,4-D choline at 1,065 g ai ha^{-1}), (2) PRE (acetochlor + fomesafen) fb 3 delayed POST applications (glyphosate + 2,4-D choline), (3) 3 timely POST-only applications (glyphosate + 2,4-D choline), (4) 3 delayed POST-only applications (glyphosate + 2,4-D choline), (5) 3 delayed POST-only applications (POST 1 of glyphosate + 2,4-D choline; POST 2 and 3 of glufosinate at 656 g ai ha^{-1} + 2,4-D choline at 1,065 g ha^{-1}), and a (6) no herbicide control (NTC). All timely POST applications were applied to Palmer amaranth 8-13 cm in height; delayed POST treatments were applied at a height of 20-25 cm. Weed control, biomass, cotton growth and yield were assessed throughout the growing season. To quantify selection pressure, weeds were counted for each plot in its entirety prior to each POST herbicide application to determine the number of plants exposed to the herbicide (newly emerged); damaged weeds surviving an application were assessed after each application documenting those plants exposed to multiple herbicide applications (previously damaged). Averaged over all locations, nearly 270,000 Palmer amaranth plants ha^{-1} were treated with the POST 1 application in the conventional system; utilizing a cover crop (5,000-9,000 kg ha^{-1} rolled rye biomass) reduced exposure 27%, however this density was reduced at least 99% by the addition of a PRE herbicide in either conventional or reduced tillage systems. The POST 2 application treated 11 to 100, 87 to 437, 9,135 to 17,548, and 21,103 to 49,982 plants ha^{-1} in the PRE-timely POST, PRE-delayed POST, timely POST, and delayed POST systems, respectively; density was reduced within each herbicide program when the cover crop was utilized. Calculated throughout the entire season, the cover crop reduced the number of Palmer amaranth plants exposed to 2,4-D by 28-29% within a POST-only herbicide system, however the use of PREs reduced exposure by at least 99%. The greatest number of Palmer amaranth exposed to multiple applications of 2,4-D during the growing season was recorded in the conventional tillage system, when POST programs were delayed (55,694 to 61,561 ha^{-1}). In this tillage system, exposure was reduced by timely applications, however PRE herbicide mixtures combined with either tillage system showed the greatest benefit in reducing Palmer amaranth exposure to multiple 2,4-D POST applications (4 to 165 plants ha^{-1}).

Evaluation of Summer Cover Crop Mixes for Suppression of Post-harvest Weed Recruits.
Jodie M. McVane*, Muthukumar V. Bagavathiannan; Texas A&M University, College Station, TX (84)

Cover crops can play a vital role in developing resilient farms. They help with weed suppression, erosion control and build healthy soils. Moreover, cover crops can be an important addition to less diverse row crop systems, while enhancing the provision of ecosystem services. Given the long growing seasons in south Texas, weeds that emerge after the harvest of corn/grain sorghum can produce ample seed prior to frost and contribute to future weed problems. The availability of a long growing season also presents an opportunity to plant summer covers to obtain multitude of benefits, including weed suppression. In particular, mixes of cover crops with various functional traits are considered to be superior over single species covers. Experiments are being conducted at Texas A&M University, College Station to evaluate various summer cover crop mixes for biomass production and weed suppression potential. A total of four cover crop mixes are being evaluated in a randomized complete block design with four replications. The four mixes are: 1) all grasses (sorghum-sudangrass, pearl millet, German millet and prosomillet), 2) two grasses+ 2 broadleaves (1 legume +1 non-legume) (sorghum-sudangrass, pearl millet, cowpea and buckwheat), 3) two grasses + 2 leguminous broadleaves (sorghum-sudangrass, pearl millet, cowpea and sunn-hemp), and 4) all broadleaves (2 legumes + 2 non-legumes) (sesame, buckwheat, cowpea, sunn-hemp). The covers were planted on Sep 1, 2020 and Oct 4, 2021, and were terminated naturally by the first killing frost. The observations include cover crop biomass, ground cover, phenological growth stage of the covers at termination, weed biomass (grass vs broadleaves), and cover crop decomposition rate following termination. Preliminary results show that mixes containing grass species, particularly sorghum-sudangrass and pearl millet provided the best weed suppression compared to the other mixes evaluated here. This research offers valuable information for developing suitable cover crop mixes for the Southeast Texas region and other comparable geographies.

Detection of Herbicide Symptomology in Cotton Using Digital Images and Machine Learning. Ubaldo Torres*[1], Bishwa B. Sapkota[1], Gaylon Morgan[2], Muthukumar V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]Cotton Incorporated, Cary, NC (85)

Herbicide-induced crop stress from off-target movement is a growing concern in cotton production, the severity of which is influenced by several factors, including crop sensitivity, herbicide chemistry, and dose. The specific herbicide that caused the injury (i.e. symptomology) and the level of damage are typically assessed through visual evaluations, which requires expert knowledge and can at times be subjective. With the advances in computer vision, there is a potential to automatically detect and classify herbicide-induced symptomology on cotton using digital images. An experiment was conducted in 2021 at the Texas A&M Research Farm near College Station, TX to detect specific herbicide symptomology and assess cotton response to herbicide exposure using digital images and machine learning models. Cotton injury from eight herbicides (nicosulfuron, 2,4-D, dicamba, atrazine, isoxaflutole, glyphosate, glufosinate, and paraquat) at three application rates (high, moderate, and low) were evaluated, along with a non-treated control. Herbicide treatments were applied with a CO_2 pressurized backpack sprayer to conventional cotton at 15-, 30-, and 60-cm-tall growth stages. Digital images were collected using a DSLR camera at 5, 7, and 14 days after herbicide applications. The VGG-16 model was implemented using TensorFlow Keras to classify cotton injury. Overall, this model effectively classified herbicides of different modes of action using 300 training samples for each herbicide, with >90% classification accuracy for cotton exposed to 2,4-D and dicamba. Findings show the great prospects of using digital image analysis for diagnosis and assessment of herbicide injury on crops. Research is ongoing to further improve classification accuracy by testing other neural networks as well as increasing the training sample size.

Confirmation of Two Unique ALS- and PPO-inhibiting Herbicide-resistant *Amaranthus retroflexus* Populations in North Carolina. Eric A. Jones*, Ryan J. Andres, Diego J. Contreras, Jeffrey C. Dunne, Charlie W. Cahoon, Katherine M. Jennings, Ramon G. Leon, Wesley Everman; North Carolina State University, Raleigh, NC (86)

Farmers have limited chemical options to control *Amaranthus* spp. in conventional soybeans, relying mainly on acetolactate synthase (ALS)-inhibting and protoporphyrinogen oxidase (PPO)-inhibiting herbicides. In 2019 (Camden County, NC) and 2020 (Pasquotank County, NC), complaints of control failures with ALS- and PPO-inhibiting herbicides on redroot pigweed (*Amaranthus retroflexus* L) were reported by two different farmers in North Carolina. Greenhouse dose-response assays confirmed that the Camden and Pasquotank County redroot pigweed populations exhibited decreased susceptibility to ALS and PPO-inhibiting herbicides compared to multiple herbicide-susceptible redroot pigweed populations, suggesting the evolution of resistance. Sequencing the ALS DNA and PPX cDNA of the redroot pigweed populations provided evidence that the Camden County population exhibited a $Trp_{574}Leu$ mutation in the ALS gene and an $Arg_{98}Gly$ mutation in the PPX2 gene. The gene sequencing provided further evidence that the Pasquotank County population exhibited an $Pro_{197}His$ mutation in the ALS gene (novel mutation in the genus and species) but no mutation was present in the PPX2 gene. The inclusion of malathion did not reverse fomesafen resistance in the Pasquotank County population. These two populations represent the first confirmed cases of PPO-inhibiting herbicide-resistant redroot pigweed in the United States; as well as the first confirmed cases of this particular herbicide resistance profile inhabiting the United States. While no mutation was found in the PPX gene of the Pasquotank County population, we suggest that this population has evolved resistance to PPO-inhibiting herbicides but the mechanism of resistance is to be determined.

Dicamba-based Herbicide Programs, Crop Rotation, and Tillage for Long-term Weed Management in Cotton. Rohith Vulchi*[1], Joshua A. McGinty[2], Muthukumar V. Bagavathiannan[1], Scott A. Nolte[1]; [1]Texas A&M University, College Station, TX, [2]Texas A&M University, Corpus Christi, TX (87)

A three-year field experiment was conducted at College Station and Thrall, TX to evaluate the role of tillage type, crop rotation, and herbicide programs for glyphosate-resistant Palmer amaranth (AMAPA) control in dicamba-resistant cotton. The experimental design used was a split-split plot design. The main plots consisted of three tillage types: no-till cover cropping, strip-till, and conventional tillage. The subplots consisted of two cropping sequences: continuous cotton for three years and a cotton-sorghum-cotton rotation; and sub-sub plots consisted of four herbicide programs: an untreated check, a weed-free check, a low input (LI), and a high input program (HI). In cotton, LI consisted of two POST applications of glyphosate (1.26 kg a.e./ha) plus dicamba (0.56 kg a.e./ha); HI consisted of fluometuron PRE (1.12 kg a.e./ha), a tank mix of glyphosate (1.26 kg a.e./ha), dicamba (0.56 kg a.e./ha), and acetochlor (1.26 kg a.e./ha) as POST, and diuron (1.12 kg a.e./ha) as a layby application. Two POST applications of glyphosate (1.26 kg a.e./ha) and regular hand weeding were carried out to maintain weed-free checks. In sorghum, LI consisted of two POST applications of atrazine (1.12 kg a.e./ha); HI consisted of dimethenamid-p as PRE (0.84 kg a.e./ha), a POST application of atrazine (1.12 kg a.e./ha) plus huskie (0.245 kg a.e./ha) and a layby application of atrazine (1.12 kg a.e./ha). Visual AMAPA control ratings were recorded at the 7, 14, 21, and 28 DA every herbicide application. The data is separated by locations and then by year because significant interactions were observed. In College Station, at 28 DA second POST application during 2019, all the treatments provided >95% AMAPA control. However, by 2021, HI provided approximately 20% greater AMAPA control compared to LI in no-till cover cropping, indicating the importance of residual herbicides and cover cropping for effective seasonal AMAPA control. At Thrall, at 28 DA second POST application during 2019, all the treatments provided >90% AMAPA control. By 2021, HI and LI programs in crop rotation sequences provided >90% AMAPA control; however, in continuous cotton cropping sequence only HI provided 95% control. These results indicate that conservation practices like cover cropping and crop rotation when integrated with residual herbicides can be a fitting alternative for the conventional practice of tillage and monocropping in Texas and highlights the importance of residual herbicides for long-term AMAPA management.

Isoxaflutole Herbicide Programs in GLIXTP Cotton. Jenny L. Dudak*, Zachary R. Treadway, Todd A. Baughman; Oklahoma State University, Ardmore, OK (88)

Isoxaflutole Herbicide Programs in GLIXTP Cotton J. Dudak*[1], Z. Treadway[1], T. Baughman[1], T. Barber[2], C. Cahoon[3], A. Culpepper[4], S. Nolte[5], A. Hixson[6]; [1]Oklahoma State University, Ardmore, OK; [2]University of Arkansas System Division of Agriculture, Lonoke, AR; [3]North Carolina State University, Raleigh, NC; [4]University of Georgia, Tifton, GA; [5]Texas A&M AgriLife Extension, College Station, TX; [6]BASF, Lubbock, TX Throughout the cotton belt, the incidence of weeds resistant to multiple herbicide modes of action is increasing at an alarming rate. Postemergence herbicides historically used in cotton production are losing efficacy due to this expanding dilemma. Integrating preemergence residual herbicides into weed management programs is one method to protect these technologies. However, this can add additional challenges since early season cotton injury is often observed with these herbicides. BASF is currently integrating a tolerance trait to isoxaflutole (HPPD inhibitor) in cotton to provide producers another tool for weed management. Studies were conducted to evaluate the use of isoxaflutole on weed efficacy, cotton response and lint yield. A multi-state research project was conducted at seven locations across the cotton belt: Tillar, AR; Ty Ty, GA; Clayton, NC; Bixby, Altus, and Fort Cobb, OK; and College Station, TX. HPPD-tolerant cotton was planted and managed based on local growing practices. The following herbicide treatments were applied PRE at 6 of 7 locations: isoxaflutole (112 g ai ha^{-1}) alone and either diuron/fluometuron (560-1120 g ai ha^{-1}) or fomesafen/fluridone (210-275 g ai ha^{-1}) alone or in combination with isoxaflutole. All PRE treatments were followed by a POST application of dicamba (560 g ae ha^{-1}) + dimethenamid-P (673 g ai ha^{-1}) + glyphosate (1648 g ai ha^{-1}) + potassium carbonate (406 g ai ha^{-1}). At Tillar, AR PRE treatments included: fluometuron (841 g ai ha^{-1}) alone or in combination with isoxaflutole (112 g ai ha^{-1}), fluometuron + prometryn (560 g ai ha^{-1}), and a three-way combination of all three herbicides. Three POST applications of various herbicide combinations were made following all PRE treatments at Tillar. Observed cotton injury was less than 10% at all locations 2 weeks after planting (WAP). Additionally, the incidence of injury did not increase when isoxaflutole was combined with other herbicides. At Altus, Bixby, Fort Cobb, and Ty Ty, isoxaflutole alone PRE controlled Palmer amaranth (*Amaranthus palmeri* S. Watson) and annual grass 97% or greater 2 WAP. Isoxaflutole + diuron was the only PRE treatment that controlled over 90% of Palmer amaranth and annual grass at all locations 4 weeks after the POST treatment. Control of Palmer amaranth and annual grass was excellent season long at Tillar, AR. Cotton lint was harvested at all three Oklahoma locations however, differences among treatments were only documented at Bixby. Diuron, fomesafen, and isoxaflutole + diuron yielded higher than isoxaflutole or isoxaflutole + fomesafen. Isoxaflutole provided control of both Palmer amaranth and annual grass while displaying excellent cotton tolerance.

Herbicide Tolerance of Hemp Grown for Grain or Fiber. Cynthia Sias*, Michael L. Flessner, Kevin W. Bamber, John Fike; Virginia Tech, Blacksburg, VA (89)

The recent increase in interest in industrial hemp production from growers has uncovered the need for weed management options in industrial hemp. There is currently no synthetic herbicide that is labeled for use in industrial hemp production in the U.S., leaving growers with limited weed control options. However, there is potential for existing chemistries to be used for weed control in hemp grown for grain or fiber. Research evaluated this hypothesis in drilled grain hemp by comparing 8 different PRE applied herbicides as well as 12 POST applied herbicides in separate experiments. Each experiment had 3 site years between 2019 and 2021. Each experiment was a randomized complete block design with four replications per treatment. Data on general phytotoxicity observed and yield were recorded and compared across treatments. Data were subjected to ANOVA using JMP Pro 16 ($p<0.05$) and mean separation was confirmed using Fisher's Protected LSD. Significant differences were observed in the general phytotoxicity observed at 60 days after application for the PRE and 30 days after application for the POST experimental plots. This information will be useful in order for regulations on chemicals to be extended for inclusion in industrial hemp production. Future ongoing research will look at the response of transplanted hemp when subjected to delayed PRE applications.

Evaluation of Pendimethalin Application Time for Seeded Onion in North Dakota. Avery Shikanai*, Collin P. Auwarter, Harlene M. Hatterman-Valenti; North Dakota State University, Fargo, ND (90)

Weed control in seeded onion (*Alium cepa* L.) is challenging due to the slow growth and poor competitive ability of onion. Multiple applications of residual herbicides are needed to achieve season-long weed control and preserve yields. However, multiple herbicide applications can cause unacceptable injury, and herbicides commonly used in onion production are costly. Pendimethalin could be a cost-effective part of an integrated weed management approach, but variable crop safety has been reported and optimal rates and application timings have not yet been determined. Therefore, herbicide programs with varying pendimethalin rates (0, 399, 799, 1598 g ai ha-1) and application timings (PRE, loop, 1-, and 3-leaf stage) were evaluated for weed control efficacy in two locations (grower field = GF and research extension center =REC) over two years. Generally, herbicide programs incorporating pendimethalin provided excellent control (>90%) of redroot pigweed (*Amaranthus retroflexus* L.) and common lambsquarters (*Chenopodium album* L.). Out of 31 unique site, year, and herbicide program combinations, poor weed control was observed 3 times. In 2020 at GF, pendimethalin applied at the loop stage provided poor control of common lambsquarters, while any rate of pendimethalin applied PRE provided unacceptable control of redroot pigweed at REC in 2021. Despite reduced weed control, there were no statistically significant yield differences. Taken together, pendimethalin can be an effective component of a weed control program for onion. However, the most consistent weed control was achieved when pendimethalin was applied with a tank-mix partner, a subsequent overlapping residual herbicide, or both.

Evaluation of Pre-emergent Herbicides for Weed Suppression Under the Plastic Mulched Raised Beds in Vegetable Production. Ruby Tiwari*[1], Nathan Boyd[2], Samira Daroub[3], Nirmal Timilsina[1], Ramdas Kanissery[1]; [1]University of Florida, Immokalee, FL, [2]University of Florida, Wimauma, FL, [3]University of Florida, Everglades, FL (91)

Herbicide application under plastic mulch in vegetable plasticulture systems is severely limited due to the potential for crop phytotoxicity. Hence, the current study conducted at Immokalee, FL, in the spring and fall seasons in 2021-aims to find strategies to improve pre-emergent herbicide efficacy and crop safety under plastic mulch in tomato production. Two rate levels (X and 2X) of s-metolachlor (0.5 pt/acre and 1 pt/acre) and flumioxazin (2 oz/acre and 4 oz/acre) were applied alone as blanket sprays or in combination with potential slow-release carriers such as hydrogel (slow-release medium), iron chelate (fertilizer), compost and herbicide safeners like avail® (fertilizer stabilizer) and grounded® (spray deposition agent), on raised beds before installing plastic mulch. The experimental design was RCBD with five replications. Tomato seedlings were transplanted two weeks after treatment, and nutsedge (*Cyperus rotundus*) counts and tomato yield were recorded. *S*-metolachlor and flumioxazin spray numerically reduced the nutsedge counts compared to control; however, the effect was not statistically significant for spring 2021. *S*-metolachlor combined with avail, grounded, and compost suppressed nutsedge emergence in fall 2021. *S*-metolachlor and flumioxazin sprays alone and in combination with test carriers did not affect the yield of tomato except for the one coated on the iron-chelate for spring 2021. Also, yield did not differ significantly among the treatments in fall 2021. Observations from this study suggest that s-metolachlor and flumioxazin application as blanket sprays or in combination with test carriers or herbicide safeners such as avail and grounded can be effectively and safely used under the plastic mulch to control nutsedge and to enhance tomato production in raised bed plasticulture productions.

Nut and Fruit Crops Response to Simulated Drift Rates of Florpyrauxifen-benzyl Drift in California. Deniz Inci*[1], Brad Hanson[2], Kassim Al-Khatib[1]; [1]University of California, Davis, CA, [2]UC Davis, Winters, CA (92)

California produces more than 99% of almonds, peaches, pistachios, prunes, and walnuts in the US. Rice herbicides are generally applied from late May to early July in the Sacramento Valley, California. At this time of the year, tree nut, peach, and plum trees are actively growing and most vulnerable to herbicides exposure. Hence, rice herbicide drift onto orchard crops is a common concern among growers. Florpyrauxifen-benzyl is a new synthetic-auxin rice herbicide recently registered in the US and is anticipated to be registered in California. Thus, this study aims to develop data on the relative sensitivity of nut and fruit crops to simulated drift rates of florpyrauxifen-benzyl. Trees were subjected to simulated drift treatments in mid-June in both the 2020 and 2021 growing seasons. Florpyrauxifen-benzyl was applied at four rates approximating drift: 0.5%, 1%, 3%, and 10% of the use rate in rice, 30 g ai/ha. Treatments were conducted as a randomized complete block with four replicates, experimental units were single trees and each species was considered a separate experiment. Florpyrauxifen-benzyl was applied to one side of the canopy in one pass from the top to the ground. A handheld, CO_2-pressurized sprayer equipped with two nozzles XR8004(AI) spray boom at 276 kPa pressure was used. Methylated seed oil at 0.58 L/ha was also added to all treatments. Visual injury was rated at 24, 48, and 72 hours and 7, 14, 21, 28, 35, 42, and 90 days after treatments using a scale where 0 means no injury and 100 means complete death. Florpyrauxifen-benzyl symptoms were observed on all trees, and visual symptoms were more apparent as herbicide rates increased; however, the severity of symptoms was greatest on pistachio. Additionally, the time to develop symptoms was shorter with pistachio than the other species. General symptoms were chlorosis, excessive branching, leaf curling, leaf narrowing, leaf distortion, leaf malformation, leaf crinkling, shoot curling, stem discoloring, stunting, terminal bud death, and twisting. Shoot curling and stunting for pistachio; leaf curling and necrosis for almond; epinasty and leaf discoloration for walnut; leaf curling and stunting for peach; and necrosis and excessive branching for prune were more apparent at higher rates of florpyrauxifen-benzyl. Pistachio was by far the most susceptible crop among the tree crops evaluated. Multi-year-treated pistachios were relatively shorter throughout the season. While most crops resumed growth and appeared normal at the end of the growing season, pistachio continued to show symptoms from the highest simulated rate for the remainder of the 2021 growing season.

Annual Bluegrass (Poa Annua L.) Seedbank Persistence: A Multi-state Study Across Plant Hardiness Gradients in the United States. Andrew W. Osburn*[1], Rebecca Bowling[2], Muthukumar V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]Texas A&M University, Dallas, TX (93)

Annual bluegrass (*Poa annua* L.) is a highly prolific and troublesome weed found in turfgrass systems across the United States (US) and beyond. This problematic plant severely impacts the aesthetic value of turfgrass fields and drastically increases control costs. Annual bluegrass has exhibited high persistence in turfgrass systems, but the role of seedbank longevity in long-term persistence of this species is unknown. In the fall of 2020, ten unique populations originating from various plant hardiness zones across the US were buried in seven locations at two depths, surface and 5 cm. For each treatment, a total of 250 viable seeds were mixed in weed-free native soil of the burial site and placed in a polyethylene mesh bag, which was buried at the respective depth in three replicates. A subset of the seed for each population has been stored under room temperature for comparison. The bags are retrieved at 6-month intervals over a period of 3 years. Upon retrieval, the bags are cut open and placed on the surface of plastic trays for germination evaluation in the greenhouse. Germination is observed at weekly intervals over the course of 6 weeks. The trays are then subjected to cold treatment (4 C) for 3 weeks to facilitate dormancy breaking and then moved to the greenhouse for further germination observations. As of now, data from the first 6-month after burial (bags retrieved in Mar/April 2021) is available. Seedbank persistence was greater in seed sources obtained from northern plant hardiness zones (5a, 6a, and 6b) exhibiting upwards of 17% remaining viability compared to those from the more southern regions (7a, 7b, 8a, 9a, and 9b) which exhibited less than 1% remaining viability at 6 months after burial. Additionally, seed buried at the 5 cm remained more viable than seed buried at the surface. The preliminary findings suggest that populations from southern locations experience either greater seed demise or exhibit greater dormancy. This is an ongoing study and results will be updated as further seed bag retrievals are evaluated.

A Comparison of Spray Deposition Patterns from the Drone and Ground-based Sprayer.
Daewon Koo*, Clebson G. Goncalves, Shawn Askew; Virginia Tech, Blacksburg, VA (95)

Agricultural spray drones (ASD) have become increasingly accessible in recent years, but little is known regarding their use for pest control. Only a few studies have evaluated weed control efficacy, and these generally focus on canopy penetration compared with conventional ground-based sprayers. (Chen et al. 2018; Martin et al. 2020) To utilize ASD for pest control, a uniform spray deposition pattern should be guaranteed to deliver recommended rates of pesticides. Field trials were conducted at Virginia Tech's Glade Road Research Facility in Blacksburg, VA, USA to examine the influence of five different spray heights (2, 4, 6, 8, and 10-m) of ASD (DJI MG-1P, China) on spray deposition pattern, and it is compared to the spray deposition pattern of a ground-based sprayer. Total 30-m x 0.3-m white craft paper was clipped on top of rigid vinyl and placed on level turf. 50% Blazon blue dye (Milliken, USA) solution was sprayed with ASD and ground-based sprayer moving perpendicular to the paper. Then, the paper was cut, scanned, and analyzed with Turf Analyzer software (Green Research Services, USA) or with the absorbance of extracted dye via spectrophotometer. Polynomial regression curves were generated for the area above, below, and total deviation from the expected deposition pattern curve. It shows that the ASD over-applied to the targeted area when flown at lower heights and under-applied when flown at higher heights. In addition, the ASDs deposition pattern improved in uniformity as the ASD height increased. In summary, the ASD operated at 8 or 10 m delivered a smoother pattern overall, less deposition in the targeted area, and more deposition outside the targeted area (significant pattern at up to 14 m on either side of the drone). The results suggest that ASD applications will deviate significantly from expected deposition patterns and more so than the deposition patterns delivered by ground-based sprayers.

Evaluation of Purestand Max and Weedmaster XHL for the Control of Johnsongrass.
Zachary S. Howard*[1], Daniel Beran[2], Scott A. Nolte[1]; [1]Texas A&M University, College Station, TX, [2]Nufarm, Eldora, IA (96)

Continued development of herbicide products for the management of difficult to control weeds such as johnsongrass (*Sorghum halepense*) within hay crops has led to the increase of premix products of herbicides that may be traditionally tank mixed. Purestand Max™ is a new premix product pending registration for the pasture market from Nufarm consisting of sulfosulfuron + metsulfuron methyl, both ALS inhibiting herbicides. WeedMaster® XHL (also pending registration) is a new high load formulation consisting of dual salt amine (MMA + DMA) of 2,4-D + diglycolamine (DGA) salt of dicamba. These products, their combination, the individual components of Purestand Max™, and a traditionally recommended premix were evaluated for their effectiveness on johnsongrass in Texas and Arkansas in 2019, 2020, and 2021, and in Alabama in 2019 and 2020. Evaluations were made 42 days after application. Due to a site by treatment interaction, Data were combined by year and are shown by location. The differences between locations largely arose from overall less efficacy at the Texas location. Furthermore, the tankmix of sulfosulfuron + metsulfuron methyl and dual salt amine of 2,4-D + diglycolamine (DGA) salt of dicamba demonstrated a moderate level of antagonism at this location, providing approximately 20% less control over sulfosulfuron + metsulfuron methyl alone, while Arkansas and Alabama observed only a less than 5% reduction in efficacy. These differences may be due to typical summer rainfall being significantly less in the summer months in Texas than the other two locations, though the lack of antagonism at these locations is unusual. All other treatments performed as expected, and the addition of metsulfuron methyl to sulfosulfuron in a premix formulation did not reduce johnsongrass control efficacy and This premix is a competitive treatment to traditionally recommended sulfosulfuron alone, or a premix of nicosulfuron + metsulfuron methyl. Overall, the new premix products will provide pasture and hayfield managers additional options for controlling this grass weed that may otherwise diminish stocking rates or hay quality.

Tracking Herbicide-Resistant Weeds in California Rice Through a Community-Driven Approach. Aaron Becerra-Alvarez*, Kassim Al-Khatib; University of California, Davis, CA (97)

Weeds are considered the major impediment for achieving optimal yields in rice production. The continued use of limited herbicides along with no crop rotations, has led to a large incidence of herbicide-resistant weeds in California rice. In support of managing herbicide-resistant weeds, the University of California (UC) Rice Weed Group and the California Rice Research Board adopted a community-driven approach to confirm or disprove suspected herbicide resistance in growers' fields. The Herbicide Resistance Weed Screening Survey invites rice growers to collect and submit weed seed samples with suspected resistance to test against registered herbicide modes of action by means of a whole-plant assay method. Weeds are grown in the greenhouse and the herbicides are applied at the 1X – 2X field rate as granular or foliar formulations and visually assessed three weeks after treatment. The results are then sent as a report to the growers or consultants before the next growing season and assist them with developing future weed management plans. Survey data from 2015 to 2020 demonstrates watergrass species (*Echinochloa* spp.), smallflower umbrella sedge (*Cyperus difformis* L.) and bearded sprangletop [*Leptochloa fusca* (L.) Kunth] have been the most prominent species submitted, indicating their increased difficultness to manage. The group 2 (ALS-inhibitors) and group 5 (PSII-inhibitors) herbicides had the highest frequency of resistance with greater than 83% of samples demonstrating resistance to the five available herbicides. The group 1 (ACCase-inhibitor) and group 15 (VLCFAs inhibitor) demonstrated 85% and 44% of resistance, respectively. While group 4 (auxin mimics), 13 (DOXP synthase inhibitor), and 14 (PPO-inhibitor) all demonstrated less than 7% resistance. Multiple resistance with up to five modes of action was observed with higher frequency for two of the watergrass species, barnyardgrass [*E. crus-galli* (L.) Beuv] and late watergrass [*E. phyllopogon* (Stapff). Koss.]. Other weed species observed higher frequency of resistance to one or two modes of action only. The Herbicide Resistance Weed Screening Survey allow UC researchers to better track herbicide-resistant weeds and discover emerging biotypes. The community-driven approach of this survey reveals an allied collaborative effort by the UC and the California rice industry in addressing the herbicide resistance issue.

Comparison of Residual Activity of Pre-emergence Herbicides for Control of Multiple Herbicide-resistant Palmer Amaranth (*Amaranthus palmeri*) in Food-grade White Corn.

Ramandeep Kaur*[1], Yeyin Shi[1], Stevan Knezevic[2], Vipan Kumar[3], Rachana Jhala[1], Nevin Lawrence[4], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]Kansas State University, Hays, KS, [4]University of Nebraska-Lincoln, Scottsbluff, NE (98)

Nebraska is the number one producer of food grade white corn in the United States. Food grade white corn has not been genetically engineered; therefore, non-selective herbicides such as glyphosate or glufosinate cannot be used. Multiple herbicide-resistant Palmer amaranth is among the most troublesome weeds to manage in agronomic crops across the mid-south, southeastern, and north central United States. Multiple herbicide-resistant Palmer amaranth populations have been reported in multiple counties in Nebraska. Management of multiple herbicide-resistant Palmer amaranth is a challenge, particularly for white corn producers. The objective of this study was to evaluate the residual activity of pre-emergence herbicides for acetolactate synthase (ALS) inhibitors/atrazine/glyphosate-resistant Palmer amaranth control and yield in food grade white corn. Field experiments were conducted during the summer 2020 and 2021 in a grower's field infested with ALS-inhibitors/atrazine/glyphosate-resistant Palmer amaranth near Carleton, NE. Averaged across herbicide programs, acetochlor/clopyralid/mesotrione, atrazine/bicyclopyrone/mesotrione/S-metolachlor, acetochlor/mesotrione provided higher grain yield and 90% to 99% control of ALS inhibitors/ atrazine/ glyphosate-resistant Palmer amaranth. The results of this research illustrate that PRE-herbicide programs are available for early season control of multiple herbicide resistant Palmer amaranth in food grade white corn.

Evaluation of an RTK-GPS Guided Unmanned Aerial System for Site-Specific Treatment of Late-Season Weed Escapes in Rice. Bholuram Gurjar*[1], Bishwa B. Sapkota[1], Isidor Ceperkovic[1], Ubaldo Torres[2], Matthew Kutugata[1], Xin-Gen Zhou[1], Daniel E. Martin[3], Muthukumar V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]Texas Tech University, Lubbock, TX, [3]USDA- ARS, College Station, TX (99)

There is increasing demand for technological innovations in agriculture that improve efficiency and economics, while reducing the negative environmental footprint of various agricultural practices. Major progress has been made in drone technologies and image analysis methods. Weed detection in drone imagery, along with the use of semi-autonomous aerial weed control systems, are emerging as viable solutions for combating weeds, while reducing chemical inputs. In this research, a pipeline involving weed detection in drone- collected multispectral imagery along with a UAS-based spray application were evaluated, targeting weed escapes in a rice field. The research was conducted at the David Wintermann Rice Research and Extension Center, Eagle Lake, TX during summer 2021. The specific objectives of this study were to1) Identify weed patches in a rice field using image analysis techniques, and 2) Compare the efficacy of the drone-based precision herbicide application with the conventional backpack spray application. The weed species targeted in this research were barnyardgrass (*Echinochloa muricata*), amazon sprangletop (*Leptochloa panicoides*), hemp sesbania (*Sesbania herbacea*) , and yellow nutsedge (*Cyperus esculentus*). Results showed that weed patches in a rice crop can be effectively detected in aerial multispectral imagery. Further, the RTK-GPS based spray application was fairly accurate in targeting the previously delineated weed patches. Findings demonstrate the potential for using machine vision and unmanned aerial systems for site-specific management of weed escapes in rice. Future improvements will include real-time weed detection and spraying using an on-board data processing system.

Response of Glufosinate-tolerant Soybean to Volatility of 2,4-D and Dicamba Turfgrass Formulations in Humidome. Estefania Gomiero Polli*, Travis Gannon; North Carolina State University, Raleigh, NC (100)

2,4-D and dicamba are post-emergence herbicides widely used to control broadleaf weeds in turfgrass systems. However, the volatilization potential of 2,4-D and dicamba has caused concern regarding the use of these herbicides. Previous studies have been conducted to understand the volatilization potential of 2,4-D and dicamba formulations used in crop systems. While some formulations used in crop systems are similar to the formulations used in turfgrass systems, the presence of adjuvants and other components in the turfgrass formulations can alter the herbicide volatilization potential. Therefore, the objective of this study was to evaluate the response of glufosinate-tolerant soybean to volatility of 2,4-D and dicamba turfgrass formulations in humidomes. Field studies were conducted from July to November 2021 at the Lake Wheeler Road Field Laboratory of the North Carolina State University in Raleigh, NC. Experimental design consisted of a complete randomized block design with three replications and two independent runs. Herbicide solutions were prepared using commercial formulations of 2,4-D and dicamba. Herbicides were applied at 1681 and 560 g ae ha^{-1} of 2,4-D and dicamba, respectively, plus one untreated check. Humidomes consisted of two plastic containers fitted with plastic valves used to attach each side of the humidome to tubes connected to an air vacuum pump and an external air entrance. One air vacuum pump per block was used to provide an airflow of 2 L min^{-1} for each humidome throughout the study. Glufosinate-tolerant soybean plants were grown under greenhouse conditions and once they reached V2 growth stage the study was initiated. One day before the study initiation, sod was harvested from a bermudagrass field maintained at 6 cm tall and cut into 18 x 15 cm pieces. Sod was then placed into 19 x 16 cm aluminum trays. For each treatment, two trays of sod were sprayed using a three-nozzle handheld CO_2 pressurized backpack sprayer (Bellspray Inc., Opelousas, LA, USA) calibrated to deliver 304 L ha^{-1} through XR8002 nozzles (TeeJet Technologies Spraying Systems Co., Glendale Heights, IL, USA) at 124 kPa. To avoid cross-contamination, sod trays were sprayed 166 m away from the experimental site and then immediately transported to the experimental site in the back of a golf utility vehicle covered with a clean plastic sheet which was replaced between treatments. After placing the trays in the humidomes, soybean plants were carefully placed and centered between the sod trays to avoid any contact with sprayed material. After plant placement, the humidomes were sealed. Humidomes were opened 24h after application and soybean plants were transferred to the greenhouse. At 28 days after application (DAA), visual estimation of injury (VEI) was recorded. VEI data were subjected to analysis of variance in SAS software (Cary, NC) version 9.4, and treatment means were computed using Fisher's least significant difference procedure (a=0.05). Additionally, contrast analysis using the SAS PROC GLIMMIX was conducted to compare formulations and rates within herbicides. The highest VEI values were observed for the dicamba treatments, DMA (72%) and DGA (64%), and the lowest for the 2,4-D treatments, DMA (21%), choline (13%), and dual-salt (8%). While 2,4-D alone treatments present lower VEI than the pre-mixed treatments (57%), dicamba alone treatments presented higher VEI than pre-mixed treatments. The findings of this study suggest that dicamba (DMA>DGA) is more likely to volatilize and injure glufosinate-tolerant soybean than 2,4-D (DMA>choline>dual salt). Additionally, the addition of dicamba to formulation containing 2,4 increases its volatility potential.

New Formulations Improve Absorption of Glyphosate in Different Weeds. Srishti Gupta*, Franck E. Dayan; Colorado State University, Fort Collins, CO (101)

Glyphosate-resistant crops (soybean, maize, cotton, canola, and sugar beet) have been widely accepted because they provide effective and inexpensive weed management systems. Glyphosate is a systemic herbicide that translocates rapidly through plants. However, leaf absorption varies considerably amongst species and some weeds are naturally more tolerant to glyphosate due to reduced absorption in the leaves. The popularity of glyphosate has imparted a great level of selection pressure which has resulted in many weed species becoming resistant to this herbicide. Nonetheless, it is still one of the most important tools used by farmers to manage their weeds. The development of new formulations improving foliar absorption of glyphosate would results in better performance of this product. Consequently, we investigated the influence of four different formulations of glyphosate on the absorption of 14C-glyphosate in two broadleaf (Palmer amaranth and lambsquarters) and two grass weeds (barnyard grass and Italian ryegrass). The four formulations were Makaze® and Makaze® K6, and a combination of Makaze® K6 + Liberate® from Nutrien Ag solutions, and RoundUp Power MAX® from Bayer Crop Science. An unformulated solution of glyphosate was used as a benchmark. Plants at grown in the greenhouse for 21 days (approximately 3- or 4-leaf stage) and were sprayed with the different formulations of the herbicide with a table sprayer delivering 15 gal/a. Once the leaf surfaces were dry, ten 1-µl droplets of ^{14}C-glyphosate mixed with each of the herbicide formulations (100,000 dpm or 1667 Bq) were applied on second fully expended leaves. Unformulated glyphosate formed spherical droplets with very poor surface contact, which resulted in low absorption. Makaze® K6 + Liberate® provided the most contact with the leaf surface of the plants treated and resulted in the best absorption of glyphosate. The other 3 formulations performed very similarly to each other.

Impact of Fertilizer Placements on Liverwort (*Marchantia polymorpha*) Growth and Competitiveness with Ornamentals in Container Production. Manjot Kaur Sidhu*, Debalina Saha; Michigan State University, East Lansing, MI (102)

Liverwort is one of the major weed problems in greenhouse container production. It competes with the ornamental plants for resources within the container, leading to reduction in quality, aesthetic, and market value of the ornamentals. Two greenhouse experiments were conducted at the Horticulture Teaching and Research Center, Michigan State University, to evaluate the effects of different controlled-release fertilizer (CRF) placements on liverwort growth and reproduction, and its competitiveness with ornamentals in container production. The CRF used in the experiments was Osmocote [17-5-11 (8 to 9 months)]. In the first greenhouse experiment, to assess the CFR placement effects on liverwort growth and reproduction, the containers were filled with substrate and four types of fertilizer placements including top dress, subdress, incorporation, and dibble were made. For subdressing and dibble, three depths of 2.54, 5.08, and 7.62 cm were considered. Control set without any fertilizer was also included. After 2 days of fertilizer application, liverwort gemmae were applied on top of the substrate in each container and all containers received irrigation daily. Percent of container surface covered by liverwort thalli was visually estimated at 2, 4, 6, 8, 10, and 12 weeks after treatment. At 12 weeks, number of gemma cups (asexual reproductive structures) produced on the liverwort thallus were counted and approximately after 28 weeks, the sexual reproductive structures (male: antheridiophores and female: archegoniophores) were counted in each container to determine any differential responses. At the end, total fresh weight of liverwort was recorded. It was found that the maximum growth (99%) of liverwort was observed in case of incorporation of CRF and minimum in dibble at 7.62 cm (34%) followed by subdressing at 7.62 cm (39%). The gemmae and archegoniophore counts were also highest in case of incorporation. Dibble and subdressing at 7.62 cm showed least liverwort growth, gemmae formation, and even lesser archegoniophore formation. The second greenhouse experiment was conducted to study the effects of CRF placements on liverwort competitiveness with a container-grown ornamental plant. Fertilizer placements in this experiment included top dress, subdress (7.62 cm), incorporation, and dibble (7.62 cm). Dracaena (*Cordyline indivisa*) plants were potted during the fertilizer placements in the containers. Gemmae application was done as in the first experiment. Approximately one week after planting, liverwort was thinned to contain either 0, 1, 3, 6, and 9 gemmalings per container. The control included a set of containers where only gemmalings were allowed to grow without any ornamental plant and with all the fertilizer placements. Growth indices of the ornamental were recorded at the beginning and at the end of experiment. At 12 weeks, liverwort thalli and plant, fresh and dry weights were also recorded. Results indicated that subdressing of CRF had highest plant fresh weight and significantly lower liverwort fresh weight. Although dibble showed minimum liverwort growth, the plants had significantly less growth in comparison to subdressing. It can be concluded that dibbling can cause phytotoxicity as the fertilizer is placed in a small pocket in direct contact with the ornamental root ball. Therefore, subdressing of CRF at 7.62 cm is recommended to control liverwort in container production, maintaining the safety of the ornamental crops.

Impact of Abiotic Stress Factors on Pollen and Stigma Characteristics of Johnsongrass.
Vikas C. Tyagi*, Aniruddha Maity, Nithya K. Subramanian, Muthukumar V. Bagavathiannan; Texas A&M University, College Station, TX (103)

Johnsongrass (*Sorghum halepense*) is an invasive, perennial weed species infesting several crops worldwide. Its high adaptive potential to diverse cropping systems and agroclimates is mainly attributed to its hardiness, resilient pollination system, and prolific fecundity. However, the effects of altered climatic variables on its pollination system, especially pollen and stigma characteristics, are largely unknown. A study was conducted under controlled environment growth chamber conditions to investigate the effects of high temperature, elevated CO_2, soil moisture stress and herbicide stress on the pollen viability and stigma receptivity of johnsongrass. Plants were grown under two levels each of temperature (ambient, ambient + 5ºC), CO_2 (400, 700 µmol mol^{-1}), soil moisture (100%, 50% field capacity), and herbicide (with and without, quizalofop (95.7% by wt) @ 0.2x). The Lugol solution (iodine/potassium iodide) was used to stain pollen to assess pollen load count and longevity under similar conditions with 15 replication (5 plants x 3 glass slides). Stigma receptivity was assessed using the H_2O_2 (conc. 25-35%) method. The pollen load per anther was assessed at 3-hour intervals for an entire day during the peak flowering time to determine johnsongrass pollen availability at a given time of the day. The longevity of freshly dehisced pollen was assessed at 0, 0.5, 1, 2, 4, 8, and 12 h intervals. The results showed that pollen load declined under elevated temperature and high CO_2 conditions by 27% and 10.5%, respectively. Further, pollen viability declined from 92% to 70% in 12 h under the ambient condition. Overall, the average stigma receptivity was 83% one day after stigma protrusion and found to be receptive for 5 days after which progressively declined with time. However, herbicide application at 10 -15 cm tall seedling stage was found to be non-significant on pollen load count and pollen longevity. Results of this study show that altered climatic variables can impact pollination biology and thereby reduce fecundity in johnsongrass. Future research will quantify the impact of these variables on seed production in this species.

Paraquat-resistant Italian Ryegrass (*Lolium multiform*) Confirmed in North Carolina. Jose H. de Sanctis*[1], Wesley Everman[1], Travis Gannon[1], Zachary R. Taylor[2], Charlie W. Cahoon[1]; [1]North Carolina State University, Raleigh, NC, [2]North Carolina State University, Sanford, NC (104)

Italian ryegrass is an obligate outcrossing species with large seed production; such characteristics predispose this weed for evolution of herbicide resistance. In the US, Italian ryegrass has developed resistance to 6 herbicide modes of action. Furthermore, this weed occurs in most US agronomic regions and can cause significant yield loss if not controlled. In the fall of 2020, multiple North Carolina growers reported unsatisfactory control of Italian ryegrass after sequential burndown applications of paraquat. The objectives of this study were to confirm evolution of paraquat-resistant Italian ryegrass biotypes and determine the level of tolerance in a whole-plant dose-response bioassay. Plants that survived sequential application of paraquat under field conditions were grown in separate greenhouses for seeds. Progeny from populations collected in the field were seeded under greenhouse conditions along with seed from four known susceptible populations. Treatments consistent of ten paraquat rates, varying from 0.0625X to 32X, where 1X represents the maximum label rate of paraquat (840 g ai ha^{-1}). Plants were harvested at 28 days after application and dry biomass weights were converted to biomass reduction. Based on the effective dose required to reduce biomass 50% (ED50), the putative paraquat-resistant Italian ryegrass biotypes were 21- to 60-fold resistant to paraquat compared to the averaged ED50 of susceptible populations. If converted to g ai ha^{-1}, the ED50 of putative paraquat-resistant population ranged from 633 to 1887 g ai ha^{-1} whereas the average ED50 of susceptible populations was 31.5 g ai ha^{-1}. This research confirms the evolution of paraquat-resistant Italian ryegrass in North Carolina. Furthermore, 4-way resistant (ALS, ACCase, glyphosate, and paraquat) Italian ryegrass also exist in the state.

Can the Increase in the Levels of CO_2 and Temperature Influence Palmer Amaranth Biotype's Growth and Development? Juliana de Souza Rodrigues*, Timothy L. Grey; University of Georgia, Tifton, GA (105)

Since the pre-industrial era, the CO_2 average in the atmosphere and temperature levels had risen about 120 ppm and 1 C, respectively. The Intergovernmental Panel on Climate Change (IPCC) estimates that CO_2 levels can reach 1000 ppm until the end of this century, and temperatures are predicted to increase at least 1.2 C. Due to these variabilities in the climate patterns, plants may experience differences regarding growth, development, anatomy, physiology, herbicide uptake, transport, and potential to control weeds properly. Palmer amaranth is one of the most troublesome weeds, and due to its high level of plasticity, this species can adapt quickly to new environmental conditions. Thus, the objective of this study was to establish a comparison between biotypes aiming better understand how the evolution of herbicide-resistant weeds interferes with plant growth, development, and phenotypic adaptation to the environment, under different CO_2 and temperature scenarios. For this experiment, seeds of glyphosate-resistant and susceptible Palmer amaranth, two glyphosate-resistant (collected in 2017 and 2020, from different locations), and one susceptible (early 2000's) biotypes, all from Georgia, US, were sowed in trays and grown in a greenhouse until they reached 8 to 10 cm in height. Seedlings were then transplanted to a 5L container using potting media and placed inside growth chambers, settle for combinations between low/high temperature and low/high CO_2 (23/33 C, 410 ppm ± 20 ppm; 23/33 C, 750 ppm ± 20 ppm; 26/36 C, 410 ppm ±20 ppm, and 26/36 C, 750 ppm ± 20 ppm). Plants received daily irrigation and proper fertilization when necessary. Three harvest dates (HD) were scheduled to start after ten days of the transplant, with an interval of 7 days between harvests. Data collected at every harvest date included plant height, number of leaves, and leaf area, following a destructive analysis for biomass quantification. These measurements were then used to quantify plant volume, leaf area index (LAI), specific leaf area (SLA cm^2/g), and Net Assimilation Rate (NAR $g.cm^{-2}$ ground area day^{-1}). Data recorded were subjected to analysis in R. Plants grown under 26/36 C, 410ppm±20 ppm were shorter than the other CO_2 and temperature combinations. In terms of biotypes, the susceptible was 12% taller than the glyphosate-resistant biotypes. The differences among the biotypes in terms of the number of leaves were also significant. However, it seems to be related to the biotype itself, not being affected directly by CO_2 and temperature. In comparison, the resistant biotypes showed 21% fewer leaves when compared to the susceptible. Conversely, leaf area did not differ across the treatments. Besides growing taller than the glyphosate-resistant biotype and having more leaves, plant volume only differs inside the CO_2 and temperature combinations. Plants grown under high temperature and low CO_2 levels (26/36 C, 410 ppm±20 ppm) showed approximately 45% reduction in volume. The results of this experiment may indicate that at the whole plant level, the temperature can play a significant role in palmer amaranth development, and CO_2 is a secondary effect. No differences were observed for LAI, SLA, and NAR among the HD. Further studies need to be conducted to evaluate CO_2 effects on plant physiology, anatomy, and how the fitness cost impacts herbicide-resistant biotypes under these scenarios.

Investigating the Potential Co-occurrence of Target-Site and Non-Target-Site Resistance to PPO Inhibitors in the Same Populations of Waterhemp (*Amaranthus tuberculatus*). Jesse Haarmann*[1], Bryan G. Young[2], William G. Johnson[1]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, Brookston, IN (107)

Widespread glyphosate resistance in waterhemp (*Amaranthus tuberculatus* (Moq.) J.D.Sauer) has resulted in increased usage of protoporphyrinogen IX oxidase (PPO) inhibitors in the past two decades. PPO inhibitor resistance (PPO-R) in waterhemp was identified in 2001, and has rapidly spread with the continuous use of PPO inhibitors, primarily in soybean production. A 2016 survey of waterhemp PPO-R revealed two populations that exhibited an exceptionally high magnitude of fomesafen resistance (16 to 17 fold) in comparison to other R populations (4 to 10 fold). This greater resistance response was not explained by frequency of R individuals, presence of novel target site mutations, or R allele zygosity. Furthermore, non-target site resistance, particularly CYP450 and GST based detoxification, is also becoming increasingly important for other herbicide groups. A major concern with increased detoxification-based resistance is the potential for broad cross resistance to several herbicide mode of action groups. We hypothesized that enhanced fomesafen detoxification was contributing to the increased resistance response in these select PPO-R waterhemp populations. Thus, our objective was to determine the potential for metabolic resistance to PPO-inhibitors in these two waterhemp populations. Waterhemp plants representing susceptible (IN-RAN, IA-340), moderate resistance (IL-BRO, IN-PIKE), and relatively higher-level resistance without TS mutations (IL-WAS, IN-DUB) populations were propagated from seed for greenhouse evaluations. These plants would be investigated for response to foliar applications of fomesafen in combination with CYP450 and GST inhibitors (malathion and NBD-Cl, respectively). The waterhemp plants were sprayed with NBD-CL 48h prior, Malathion 2h prior, NBD-Cl followed by Malathion, or blank DMSO solvent solution prior to being sprayed with fomesafen at rates of 0, 20, or 60 g ai ha^{-1}. Malathion and NBD-Cl applications without fomesafen resulted in stunting that was variable by population and was most severe for IN-DUB. At the 20 g ai ha^{-1} fomesafen rate, there were no differences in waterhemp control 14 days after fomesafen application for any of the detoxification inhibitor treatments. At the 60 g ha^{-1} rate, malathion + NBD-Cl increased control of IL-WAS by 20 to 26 percentage points in comparison to no inhibitor and NBD-Cl alone. While this statistic appears to support our hypothesis, the lack of consistency between high and low herbicide rates, and the noticeable phytotoxic response to malathion and NBD-Cl renders it impossible to rule out additive effects from the multiple xenobiotics applied. Further research that accounts for the many unvalidated assumptions about the action of detoxification inhibitors applied to foliage as well as the issue of phytotoxicity of malathion and NBD-Cl by themselves will be necessary to fully test our hypothesis. We recommend that researchers pursuing evidence of detoxification-based resistance utilize a full isobole analysis for more robust evidence of synergy, or use methods that measure herbicide degradation such as C^{14} or chromatography-based assays.

Protective Effect of Melatonin Against 2,4-D Injury in Cotton. Josiane C. Argenta*[1], Alyssa L. Miller[1], Antonio Augusto Tavares[1], Te-Ming (Paul) Tseng[2]; [1]Mississippi State University, Starkville, MS, [2]Mississippi State University, Mississippi State, MS (108)

Melatonin (N-acetyl-5-methoxytryptamine) is a well-known molecule for regulating sleep, mood, immune system and others, in humans and animals. Melatonin is an essential molecule in physiological processes such as germination, photosynthesis, flowering, senescence, and others in plants. In the recent years, melatonin has been shown to protect against biotic and abiotic stressors. It also has been suggested that melatonin can act as an essential reactive oxygen species (ROS) scavenger, protecting plants against herbicide damage. Therefore, the objective of this study was to evaluate the effect of melatonin in cotton sprayed with sublethal doses of 2,4-D. Plants were grown in the greenhouse at an average temperature of 35°C/25°C (day/night). When plants were at the two expanded leaf stages, melatonin at 100µM was added by drenching the soil for 3 consecutive days. In non-melatonin treatment, the soil was drenched with distilled water. Following melatonin treatment, all plants were sprayed with 0, 5, 25, 50, and 75% of 2,4-D field rate (0.8 kg/ha^{-1}). Herbicide injury was evaluated at 7, 14, 21, and 28 days after application (DAA). At 28 DAA, shoot and root biomass were collected. The data were subjected to analysis of variance (ANOVA) at a= 0.05 using the software R®. At 5% of 2,4-D, plants treated with melatonin showed significantly lower herbicide injury when compared to no-melatonin treatment (p=<0.001). Although melatonin-treated plants had a higher shoot and root biomass, the difference was not significant when comparing plants sprayed with 5% of 2,4-D. When 25, 50, and 75% of the field rate were applied, no significant injury between melatonin treated and untreated plants were found. Further research needs to be conducted to confirm our findings. Melatonin may act as a ROS scavenger, but only at the lower rate of 2,4-D. At higher herbicide rates, plants may require more prolonged melatonin treatment to induce their defense mechanisms.

Integrating Fall-Planted Cover Crops for Weed Suppression in the Semiarid Central Great Plains. Sachin Dhanda*[1], Vipan Kumar[1], Anita Dille[2], Augustine Obour[1], John Holman[3]; [1]Kansas State University, Hays, KS, [2]Kansas State University, Manhattan, KS, [3]Kansas State University, Garden City, KS (110)

Integrating Fall-Planted Cover Crops for Weed Suppression in the Semiarid Central Great Plains Sachin Dhanda*, Vipan Kumar, Anita Dille, Augustine Obour, and John Holman Department of Agronomy, Kansas State University The widespread evolution of multiple herbicide-resistant (MHR) kochia [*Bassia scoparia* (L.) A. J. Scot] and Palmer amaranth (*Amaranthus palmeri* S. Watson) poses a serious management challenge in the semiarid Central Great Plains (CGP). A field study was established in fall 2020 at Kansas State University Agricultural Research Center near Hays, KS to determine the impact of fall-planted cover crop (CC) on 1) MHR kochia and Palmer amaranth suppression (density and biomass reduction) and 2) Palmer amaranth emergence dynamics in subsequent grain sorghum. A CC mixture (67 kg ha^{-1}) of triticale (60%), winter peas (30%), radish (5%), and rapeseed (5%) was planted after wheat harvest. The CC was terminated at triticale heading stage on May 26, 2021 by using 1) glyphosate at 1260 g ha^{-1} and/or 2) glyphosate at 1260 g ha^{-1} + (acetochlor at 1665 g ha^{-1} + atrazine at 826 g ha^{-1}). A chemical-fallow (chem-fallow) treatment (without CC) was also included for comparison. The study site was planted with grain sorghum hybrid 'DKS 38-16' on June 10, 2021. Total weed density and biomass were measured at 0, 30, 60, 80, and 140 days after CC termination (DAT) using two 1 m^2 quadrats randomly placed in each plot. Additionally, two permanent quadrats (1 m^2) were placed in the center of each plot to record emergence of Palmer amaranth at weekly interval by counting and removing emerged seedlings. The CC mixture produced an average of 1523 kg ha^{-1} above-ground biomass at termination. Total weed density was reduced by 98 and 95% at 0 and 30 DAT, respectively, in CC terminated with glyphosate + (acetochlor + atrazine) compared to chem-fallow. No difference in weed density was observed at later evaluations. At grain sorghum harvest, CC terminated with glyphosate and glyphosate + (acetochlor + atrazine) reduced total weed biomass by 61% and 73%, respectively compared to chem-fallow. The time taken to reach 10, 50, and 90% cumulative emergence of Palmer amaranth was delayed by 9, 15, and 21 days, respectively, in CC terminated with glyphosate and 11, 39, and 128 days, respectively, in CC terminated with glyphosate + (acetochlor + atrazine) as compared to chem-fallow. Grain sorghum yield did not differ among CC and chem-fallow treatments. These results suggest that fall-planted CC mixture can play a crucial role in managing MHR kochia and Palmer amaranth in the semiarid CGP region.

Developing a Real-time Weed Detection System for Efficient Site-Specific Weed Management with UAVs. Bishwa B. Sapkota*, Muthukumar V. Bagavathiannan; Texas A&M University, College Station, TX (112)

Detecting late-season weed escapes at the individual plant level and treating them with herbicides at great precision is no longer a myth. Currently, this process is accomplished in three steps: 1) image acquisition with unmanned aerial systems (UAV) in the field, 2) image-stitching, processing, and analysis in the computer laboratory, and 3) precision spraying using image analysis derived geo-coordinates. This entire process can at times be lengthy, laborious, and unproductive. Here, we propose a system that improves and accelerates the weed detection and herbicide application process. The system we developed has two components: 1) a module (camera plus on-board data processor) capable of real-time weed detection, and 2) a web interface that facilitates actionable data retrieval. The camera system comprises of an Arducam® 12 MP HQ CSI camera for imaging, a Jetson nano®-4GB GPU memory for real-time image processing, and an Emlid Reach® – M GPS module for recording real-time kinetic-GPS coordinates. The web interface system displays detected weed coordinates with Google-earth base imagery and information about weed size/count, and includes an option for the users to download shapefiles containing geo-coordinates. The system also determines treatment zones using an unsupervised machine learning algorithm and generates shapefiles for them. In the preliminary investigation, Italian ryegrass (Lolium perenne ssp. multiflorum) plants in a fallow land were targeted as a proof of concept. The single-shot detector, a popular deep learning model, was trained to detect ryegrass and the trained model was embedded in Jetson nano for real-time detection. Preliminary results show that weeds can be effectively detected with onboard processing. However, geo-coordinates obtained with this approach may entail large errors due to a lack of corrections for roll, pitch, and yaw during the UAV flight. Further investigations are being made to improve the accuracy of weed detection and geo-coordinate extraction.

CWSS Student Posters

Herbicide Tank Mixtures Affect Speed and Efficacy of Winter Rye (*Secale cereale*) Termination. Olivia M. Noorenberghe*[1], Francois Tardif[1], Peter Sikkema[2], Mike Cowbrough[3], David Hooker[2], Peter Smith[1]; [1]University of Guelph, Guelph, ON, Canada, [2]University of Guelph, Ridgetown, ON, Canada, [3]OMAFRA, Guelph, ON, Canada (114)

Due to the wide adoption of no-till agriculture, North American crop production is highly dependent on herbicide use for termination of cover crops. Along with this, there is a growing demand for producers to maintain herbicide stewardship and produce economically sustainable crops in a competitive global market. Two distinct studies were conducted to evaluate the efficacy of several herbicide tank mixtures on the speed of rye burndown. Four field experiments were conducted in 2021 in southwestern Ontario to determine if the addition of glufosinate (500 g a.i. ha^{-1}), 2,4-D (choline salt, 55.7%) (834 g a.e. ha^{-1})1 or glufosinate co-applied with 2,4-D (choline salt), antagonizes winter rye control with glyphosate (900 g a.e. ha^{-1}), clethodim (45 g a.i. ha^{-1}) or quizalofop-p-ethyl (36 g a.i. ha^{-1}). Four more trials were also conducted to determine if the addition of rimsulfuron (15 g a.i. ha^{-1}) and mesotrione (100 g a.i. ha^{-1}) or both co-applied, to glyphosate (900 g a.e. ha^{-1}) could enhance winter rye control, as well as if there was a difference between UAN or water as a herbicide carrier. Winter rye control was assessed 1,2,3 and 4 weeks after application (WAA) and biomass was taken 4 WAA. Quizalofop-p-ethyl, and clethodim controlled winter rye 53 and 45% 4WAA; control increased to 71% and 53% with the addition of glufosinate. However, these interactions were still identified as antagonistic. Similarly, antagonism was observed at all sites across 1, 2, 3 and 4 WAA between glyphosate and glufosinate. 2,4-D also antagonised the two graminicides (quizaofop-p-ethyl and clethodim), however it had an additive effect when combined with glyphosate. There was no difference between UAN or water as a carrier, and the addition of rimsulfuron and/or mesotrione to glyphosate did not enhance winter rye termination. It is concluded that glyphosate was the fastest and most effective option for termination of winter rye in both trials, with glyphosate + 2,4-D providing similar control to glyphosate alone.

Effect of Fall Mowing Height on Flazasulfuron and Glufosinate Efficacy on Hair Fescue (*Festuca filiformis*) in Lowbush Blueberry. Janelle M. MacKeil*[1], Scott N. White[2]; [1]Dalhousie University, Truro, NS, Canada, [2]Dalhousie University, East Mountain, NS, Canada (116)

Hair fescue is a tuft-forming perennial grass in wild blueberry fields that reduces yields and inhibits harvest. Hair fescue can be managed with fall bearing year flazasulfuron applications, but it is unclear if herbicide efficacy is affected by fall mowing. The objective of this research was to determine the effect of mowing on fall bearing year flazasulfuron efficacy on hair fescue in wild blueberry. The experiment was a 3 X 3 factorial arrangement of herbicide (none, flazasulfuron [50g a.i. ha-1], flazasulfuron + glufosinate [50g a.i. ha-1 + 750g a.i. ha-1]) and mowing treatment prior to herbicide application (no mowing, mow high, mow low) arranged in a randomized complete block design with 5 blocks. The trial was established in two recently harvested but unmowed wild blueberry fields near Truro, NS, Canada. Mowing was conducted with a rotary mower and height of the fescue leaf canopy in the no mowing, mow high, and mow low treatments was 18 ± 0.2, 10 ± 0.2, and 4 ± 0.2 cm, respectively. There was a significant effect of herbicide treatment ($P < 0.0001$) but not mowing ($P = 0.05$) or the mowing by herbicide interaction ($P = 0.9060$) on summer total and flowering hair fescue tufty density and fall total tuft density. Fall bearing year flazasulfuron and flazasulfuron + glufosinate applications gave similar reductions in hair fescue summer flower tuft density regardless of mowing treatment. Flazasulfuron + glufosinate gave greater reductions in summer total hair fescue tuft density than flazasulfuron alone when herbicides were applied without mowing. Reductions in summer and fall total tuft density, however, were similar when these treatments were applied after both high and low mowing. Results suggest that flazasulfuron should be applied in tank mixture with glufosinate if applied before mowing but that flazasulfuron can be applied alone or in tank mixture with glufosinate if applied after high or low mowing.

Evaluation of ALS Herbicide Resistance in Three Manitoba Redroot Pigweed (*Amaranthus retroflexus* L.) Populations. Sampa Sarker*[1], Robert Gulden[1], Martin Laforest[2]; [1]University of Manitoba, Winnipeg, MB, Canada, [2]Agriculture and Agri-Food Canada, St-jean-sur-richelieu, QC, Canada (117)

Redroot pigweed (*Amaranthus retroflexus* L.) is a common broadleaf weed species in Manitoba, Canada. Producers in this region have been reporting reduced response of this weed to commonly used Acetolactate synthase (ALS) inhibiting herbicides. Three suspected resistant populations of redroot pigweed were compared to known susceptible populations in a greenhouse study to determine the level and mechanism of resistance of these populations to the ALS-inhibiting herbicides imazethapyr and thifensulfuron. Dose response curves to these herbicides indicated that all three pigweed populations were resistant to imazethapyr (~30 to >170-times), but only one of these populations showed a low level of resistance to thifensulfuron. ALS sequence analysis detected a $Ser_{653}Asn$ amino acid substitution that was consistent in the two populations resistant to imazethapyr only while a $Ser_{653}Ile$ substitution was more common in the population resistant to both imazethapyr and thifensulfuron. Non-target site resistance (NTSR) was observed in only one of the populations resistant to imazethapyr. These results expand on the known florasulam-resistant redroot pigweed population in Manitoba to include active ingredients from additional ALS-inhibitor families and show that the mechanisms and levels of resistance to common ALS-inhibitors are not the same among these redroot pigweed populations.

Evaluation of Hair Fescue (*Festuca filformis*) Management in Wild Blueberry (*Vaccinium angustifolium* Ait.) Using Casoron. Craig B. MacEachern*[1], Travis J. Esau[1], Scott N. White[2], Qamar U. Zaman[1]; [1]Dalhousie University, Truro, NS, Canada, [2]Dalhousie University, East Mountain, NS, Canada (118)

This study used a generalized randomized block design to understand the effect of dichlobenil (Casoron G4) on hair fescue (*Festuca filiformis)* management in wild blueberries (*Vaccinium angustifolium Ait.*). In particular, the effect of application method (spot and broadcast), along with the effect of application rate were analyzed. Across all analyses, there was a significant interaction between field and treatment, demonstrating the potential variability of treatment effect by location. For each analysis, Casoron G4 was analyzed against the industry standard propyzamide (Kerb SC) as well as an untreated negative control. For living tuft density, application method saw no statistical differences between Casoron G4 and Kerb SC in two of the three fields. Both Casoron G4 application methods were statistically better than the negative control in all treatments in the application method trial. For the rate trial, Casoron G4 and Kerb SC were statistically similar in one field but Casoron G4 underperformed Kerb SC in the other two. Both the medium and high rates of Casoron G4 were statistically better than the negative control. Casoron G4 and Kerb SC had similar effects on flowering in two of the three fields while the high rate of Casoron G4 had the same effect as Kerb SC on flowering. In all, the results demonstrate the potential for Casoron G4 to manage hair fescue in wild blueberries. This result is encouraging as Kerb SC is currently the only widely employed herbicide for managing this economically destructive weed. This study will proceed with a second year of data collection before concluding on the efficacy of Casoron G4 for managing hair fescue.

General Posters

Herbicide Resistance Updates for New York State. Lynn M. Sosnoskie*, Elizabeth C. Maloney; Cornell University, Geneva, NY (120)

As of December 2021, the International Survey of Herbicide Resistant Weeds, 509 unique cases of resistances have been reported, globally, across 266 species (153 dicots and 113 monocots) (Heap, I. 2021. The International Herbicide-Resistant Weed Database. Available www.weedscience.org). Currently, New York (NY) has only four confirmed resistance reports; this accounting is inaccurate according to grower, cooperative extension, and industry assessments of current weed control efforts and success. Particular weeds of concern include horseweed/marestail (*Erigeron canadensis*), Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus*). Horseweed/marestail is widespread throughout NY state. In 2020 and 2021, seed from 30 horseweed populations, the majority of which came from agronomic systems, were collected fore resistance screening. Results from greenhouse trials indicate that the majority of populations are resistant to glyphosate, chlorimuron, and chloransulam at 1X rates (0.87, 0.013, and 0.42 kg ai/ha, respectively) labeled for use in soybean (80% to 87% survival). Two populations, one from grapes in Ontario County and one from apples in Wayne County (both counties in Central NY), were susceptible to glyphosate at rates ranging from1X to 4X, but survived paraquat at 0.5 and1.0 kg ai/ha (biomass 30% to 80% of the untreated check); other horseweed/marestail were completely controlled by paraquat at these doses. Palmer amaranth populations have been reported in four counties in NY: Steuben, Seneca, Wayne and Orange. Results from preliminary greenhouse studies (conducted on the Steuben population) indicate that the population is likely resistant to glyphosate at 1X and 2X use rates (biomass 40% of the untreated check). With respect to chlorimuron and chloransulam, Palmer amaranth biomass in the 1X to 4X treatments, relative to the untreated check, ranged from 35% to 75%. The Steuben population appears to be sensitive (100% injury) to other chemistries registered in ag and specialty crops (including glufosinate, caparol, linuron, oxyfluorfen, fomesafen, and mesotrione). Waterhemp has been identified in 14 counties in NY, including: Erie, Niagara, Orleans, Genesee, Livingston, Ontario, Wayne, Yates, Seneca, Cayuga, Tioga, Oneida, Jefferson, and Washington. In preliminary screens, a population from Ontario County was assessed and is likely resistant to glyphosate at 1X to 4X rates (biomass 40% to 60% of the untreated check). With respect to chlorimuron and chloransulam, waterhemp biomass in the 1X to 4X treatments, relative to the untreated check, ranged from 75% to 130%. This population appears to be sensitive (100% injury) to other chemistries (see above). We are currently in the process of conducting dose response assessments on horseweed/marestail, Palmer amaranth and waterhemp. 2022 work will also evaluate Powell amaranth (*Amaranthus powellii*) responses to PPO-inhibiting herbicides and common ragweed (*Ambrosia artemisiifolia*) and perennial sowthistle (*Sonchus arvensis*) responses to clopyralid.

Efficacy of Weed Management Tactics Poster: an Opportunity for Feedback. Michael L. Flessner*[1], Mark VanGessel[2], Kevin W. Bamber[1], Thierry E. Besancon[3], Rakesh S. Chandran[4], Dwight Lingenfelter[5], Claudio G. Rubione[2], Lovreet S. Shergill[6], Vijay Singh[7], Kurt M. Vollmer[8], John M. Wallace[5]; [1]Virginia Tech, Blacksburg, VA, [2]University of Delaware, Georgetown, DE, [3]Rutgers University, Chatsworth, NJ, [4]West Virginia University, Morgantown, WV, [5]Penn State University, University Park, PA, [6]Montana State University, Huntley, MT, [7]Virginia Tech, Painter, VA, [8]University of Maryland, Queenstown, MD (121)

Multiple weed control tactics are widely recommended for optimizing weed management outcomes and mitigating herbicide-resistance. Extension resources are available for the integrated weed management of many troublesome weeds in field crops, but resources that integrate the multiplicity of weeds, management tactics, and crop rotations do not exist. Therefore, a poster was created to simplify integrated weed management in row crops (available at https://agweedsci.spes.vt.edu/extension/publications/iwm.html). The poster is based on similar resources for relative herbicide efficacy. The poster contains two tables that rate weed management tactics either before planting (focusing on winter weeds and early emerging weeds) or after planting (focusing on weeds encountered during the crop season). Weed control tactics are listed chronologically through crop season and include broad categories of crop rotation, cover crops, tillage and cultivation, planting, fertility, post-harvest, equipment sanitation, and herbicides. Relative efficacy of weed control tactics were rated by experts across the mid-Atlantic region. Descriptive terms of Detrimental, No effect, Poor, Fair, Good, and Excellent were used instead of a numerical scale due to the variability of some tactics. The tables allow users to easily and quickly identify and compare efficacy across a range of integrated weed management tactics. We welcome feedback to improve the poster. Feedback could be on efficacy ratings for a weed and tactic combination(s), revisions to expand the poster beyond the mid-Atlantic region, layout and presentation, rating scale, and/or any other constructive criticism. Please share your critique by adding comments to this file: https://drive.google.com/file/d/177NWZy7DypRl2EBwXCbDJCStckJQ1ygx/view?usp=sharing or by scanning this QR code:

***Thlaspi arvense* Response to Carryover of Corn Herbicides in the Field and Greenhouse.**
Mark Bernards*, Brent S. Heaton; Western Illinois University, Macomb, IL (123)

Field pennycress (*Thlaspi arvense*) is being domesticated as a winter annual oilseed crop. Commercial varieties will be marketed as a new crop: "CoverCress." It is anticipated that oil extracted from covercress seed will be used as a biofuel (likely for the aviation industry), meal will be incorporated into livestock feed rations, and the crop will provide winter cover and reduce nutrient loss to tile drainage. The current production model targets planting covercress following corn. Some plant breeders have reported issues with herbicide carryover affecting stand and yield of pennycress. The objectives of this research were to 1) simulate herbicide carryover and evaluate pennycress response in greenhouse studies, and 2) evaluate pennycress stand and yield following field applications of common corn herbicides in the preceding corn crop. In greenhouse studies, herbicide doses were based on half-life values and expected herbicide residues in the soil up to 90 days after herbicide application. All herbicides were applied as single active ingredient products. Pennycress was planted in an amended soil (67% silt loam, 16% perlite, and 16% sand) prior to herbicide application. Pennycress stand was counted 3 and 5 weeks after planting and dry weights were measured at harvest. In field studies, commercial corn premixes were applied at the labeled rate and two times the labeled rate in May and June. Corn was harvested as silage, and pennycress was drilled into the plots shortly after harvest. Pennycress stand was counted in the fall and spring, and yield was measured the following spring. In greenhouse studies, pennycress stand count increased as herbicide application rate decreased (simulating declining herbicide carryover with time) for mesotrione, tembotrione, isoxaflutole, topramezone, safulfenacil, atrazine, rimsulfuron, S-metolachlor, pyroxasulfone, acetochlor, dimethenamid-p and 2,4-D. Pennycress stand was not affected by clopyralid, dicamba, thiencarbazone, and tolpyralate dose. All Group 27 herbicides tested, except tolpyralate, affected pennycress stand similarly, but had no effect at the dose representing 5 half-lives, or 75+ days after application. Of the Group 15 herbicides, pyroxasulfone reduced stand counts severely. The treatment dose representing 4 half-lives (approximately 80 days after application) for acetochlor, *S*-metolachlor, and dimethenamid-p had stand counts equal to the untreated check. The interval between PRE herbicide application in corn and pennycress planting will be approximately 120 days, and between a POST herbicide application and pennycress planting approximately 90 days. In field studies initiated in 2020 and harvested in 2021, there were no differences among treatments in fall and spring stand counts nor in pennycress seed yield. Unless circumstances impede the normal degradation of herbicides in the soil (drought, limited microbial activity, little organic matter, etc.) it appears unlikely that herbicide carryover from corn will reduce pennycress stand.

Pesticide Drift Complaints Decline While Dicamba Technology Adoption Increases. A Stanley Culpepper*, Jenna C. Vance, Taylor M. Randell, Hannah E. Wright; University of Georgia, Tifton, GA (124)

Adoption of dicamba-tolerant technologies across Georgia has been rapid, with greater than 70% of soybeans and 90% of cotton planted being tolerant to topical dicamba applications during 2021. In conjunction with the technologies, growers quickly implemented dicamba-based programs to improve their overall weed management programs, especially for Palmer amaranth. Over 57% of Georgia farmers reported weed control was improved over 50% when adopting a dicamba system, with another 32% of those growers reporting the dicamba system improved weed control 20 to 50%. With pesticide stewardship being critically important to the sustainability of humankind, the University of Georgia Extension and the Georgia Department of Agriculture teamed up to create the first of its kind large-scale classroom and on-farm training program titled “Using Pesticides Wisely” in 2014. The program has included the following: 1) Over 125 field experiments conducted across the state developing methods to improve on-target pesticide applications; 2) in-person classroom training events at 153 locations; 3) Extension Agents conducting one-on-one in-person trainings for over 1,000 pesticide applicators, helping them make better decisions when applying pesticides; and 4) during the pandemic, educational programs continued with a mixture of both virtual (15 webinars) and in-person trainings following safety guidelines. The Using Pesticides Wisely program collectively trained 11,379 pesticide applicators since its inception, leading to a 90% reduction in pesticide drift complaints documented by the University of Georgia Cooperative Extension Service. Additionally, the Georgia Department of Agriculture has only confirmed one dicamba drift complaint from use in agronomic crops since the commercialization of the auxin technologies during 2016. Numerous other factors are influencing the advancement of pesticide stewardship in Georgia; most notably are the wise decisions growers and pesticide applicators are making each and every day.

Isolation and Identification of Allelochemicals from Root Exudates of Cotton Chromosome Substitution Lines Known to Suppress Palmer Amaranth. Alyssa L. Miller*; Mississippi State University, Starkville, MS (126)

Weedy plant species have been and continue to be an extreme issue affecting crops, including cotton. A specific weed type that is of major hinderance to cotton (*Gossypium hirsutum)*, in particular, is known as Palmer amaranth (*Amaranthus palmeri). Plamer amaranth's ability to form herbicide resistance has created a dire need for substitute methods in controlling weed populations, besides the most common form- chemical control by way of herbicides. In the study administered, eleven separate chromosome substitution (CS) lines of cotton plant were earlier tested for weed suppressive components were utilized in the current study at hand. The CS lines chosen with expected allelopathic results based on field and greenhouse screenings were as follows: CS-23, CS-34, CS-46, CS-49, CS-50, CS-26, UA48 (conventional cultivar), and TM1 (the parent cotton line). These lines were tested using HPLC analysis for allelopathic chemicals*. There CS lines were germinated until two embryonic leaves known as cotyledons appeared for each seedling and then transferred to test tubes filled with distilled water. When preparing the standard solution for HPLC analysis calibration, the following reagents were used: chlorogenic acid, caffeic acid, courmarin, transcinnamic acid, coumaric acid, 2-hydroxyinnamic acid, vanillian, and p-hydroxybenzoic acid. Chromatogram readings for the analysis detected a peak very similar to that of chlorogenic acid in one of the CS-23 samples at 28 days after establishment (DAE). The creation of new allelopathic cotton CS varieties could be crucial to the successful battle against herbicide- resistant weeds growing among cash crops. Although much is factually known about the topic of allelopathy, more research and discovery need to be accomplished for these specific allelopathic CS lines to suitably be used in agricultural environments.

Making Room for Diversity: Evaluating the Relative Sensitivity of Cover Crops to Residual Herbicides in Corn. John Wallace*, Tosh Mazzone; Penn State University, University Park, PA (127)

Integrating cover crops in no-till crop production systems increases crop diversity, decreases soil erosion, and increases soil biological health. To maximize these ecosystem services, growers are prioritizing cover crop seeding directly after crop harvest, experimenting with cover crop interseeding in corn and soybean, and utilizing diverse cover crop mixtures. Greater understanding of the potential for residual herbicides to injure or reduce establishment rates of cover crops is needed to consistently realize conservation goals. In support of recent field trials, we conducted a series of greenhouse dose response assays that evaluated the response of twelve cover crop species to commonly used seedling shoot (Group 15) and seedling root (Group 3) inhibiting herbicides. Three experiments (grass, legume, non-legume cover crops) were conducted using a three-factor RCB design with five replicates and two experimental runs. Experimental factors included four cover crop species and five herbicides (acetochlor, dimethenamid, S-metolachlor, pyroxasulfone and pendimethalin) applied at seven rates standardized based on label rates (1X, 1/2 X, 1/4 X, 1/8 X, 1/16X, 1/32X, 0X) for medium-textured soils in corn. Cover crop species included annual ryegrass (Kodiak), cereal rye (VNS), triticale (Elevator), sorghum sudangrass (AS5201), crimson clover (Dixie), medium red clover (VNS), hairy vetch (Purple Bounty), Austrian winter pea, winter canola (Wichita), Daikon radish, forage rape (Dwarf Essex), and buckwheat (Lifago). Experiment units (pots) were filled with 2:1 sand to potting mix medium and sown with five cover crop species prior to application of herbicides at 15 gpa in a track sprayer. Aboveground biomass was harvested 28 DAT, dried and weighed. Sigmoidal models (log-logistic, Weibull) were fit for each herbicide by cover crop combination and the ED50 parameter estimate and 95% confidence intervals were used to compare relative sensitivities. Annual ryegrass and sorghum sudangrass were more sensitive across herbicides compared to triticale and cereal rye, which were tolerant to pyroxasulfone and pendimethalin at 1X rates. Crimson clover was the most sensitive legume species across herbicide treatments and acetochlor was the most injurious herbicide across legume species, with mean ED50 values below 1/8X product rates. Brassica cover crops (canola, rape, radish) were tolerant at 1X rates to pendimethalin, S-metolachlor and dimethenamid but were highly sensitive to pyroxasulfone. Buckwheat was tolerant to pendimethalin but highly sensitive to seedling shoot inhibiting herbicides. When coupled with field-level observations, these results can be utilized to generate rules-of-thumb and general guidelines for integrating diverse cover crop mixtures into annual crop rotations, or conversely, to select herbicide programs that limit impact on cover cropping programs. Current work has expanded this methodology to Group 27 herbicides in combination with atrazine in order to inform corn herbicide programs.

Enhanced Metabolism Confers Imazamox Resistance in Shattercane Populations. Vipan Kumar*[1], Rui Liu[1], Ramasamy Perumal[1], Sarah Morran[2], Todd A. Gaines[2], Brent Beans[3]; [1]Kansas State University, Hays, KS, [2]Colorado State University, Fort Collins, CO, [3]United Sorghum Checkoff Program, Lubbock, TX (128)

Shattercane [*Sorghum bicolor* (L.) Moench ssp. *Drummondii*] is a problematic summer annual grass weed species in grain sorghum producing regions, including Kansas. Recent development of grain sorghum hybrids with tolerance to acetolactate synthase (ALS)- and acetyl-CoA-carboxylase (ACCase)-inhibiting herbicides will allow producers to use these herbicides for in-season selective control of shattercane. In a recent field survey, three shattercane populations (DC8, GH4, and PL8) collected from sorghum fields from northwestern Kansas survived the field-use rate (52 g ha^{-1}) of POST applied imazamox. The main objectives of this research were to (1) confirm and characterize the level of resistance to imazamox in those putative imazamox-resistant (IMI-R) shattercane populations, (2) investigate the underlying mechanism of resistance, and (3) determine the effectiveness of alternative POST herbicides for controlling IMI-R shattercane populations. An imazamox susceptible shattercane population collected from a sorghum field in Rooks County, KS was also included. Based on percent shoot dry weight reduction (GR_{50} values), all three putative populations exhibited a 3.6- to 5.2-fold resistance to imazamox compared to the SUS population. The *ALS* gene sequences from the three IMI-R populations did not reveal any known target-site resistance mutations. Treatment with malathion followed by imazamox at 52 or 104 g ha^{-1} increased control (87 to 95%) and shoot dry weight reduction (up to 95%) for all three IMI-R shattercane populations relative to malathion alone treatment, indicating a possible metabolism-based mechanism for imazamox resistance. In a separate greenhouse study, the IMI-R populations were susceptible to POST treatments of nicosulfuron, quizalofop, clethodim, and glyphosate with control ranging from 98 to 100%. The lack of known *ALS* target-site mutations, and the reversal of resistance phenotype by the cytochrome P450 inhibitor (malathion) suggest the evolution of metabolism-based resistance to imazamox in shattercane populations.

Roughstalk Bluegrass Control in Winter Wheat. Christy L. Sprague*, Gary Edward Powell, Brian J. Stiles II; Michigan State University, East Lansing, MI (129)

Roughstalk bluegrass (*Poa trivialis*) is a cool-season perennial grass that has become a major weed problem in several Michigan winter wheat fields. This perennial weed acts more like a winter annual in wheat, with a majority of emergence occurring in the fall. Field research was conducted for four years examining different roughstalk bluegrass management strategies in winter wheat. Mesosulfuron, pyroxsulam, and pinoxaden + fenoxaprop were applied in the fall, early spring, and late spring when winter wheat was at Feekes stage 1.2-1.3, 4-5, and 6-7, respectively. Roughstalk bluegrass control was greatly influenced by the time of herbicide application. Across all herbicide treatments roughstalk bluegrass was most effectively controlled by early-spring (EPOS), followed by fall (FALL) applications, whereas late-spring applications (POST) typically resulted in unacceptable control in two of four years. Roughstalk bluegrass was 7.6 cm or less for the EPOS application, whereas roughstalk bluegrass started to head out for some of the POST applications. Excellent roughstalk bluegrass control was also observed with mesosulfuron and EPOS applications of pinoxaden + fenoxaprop. Control with pyroxsulam was more variable and was up to 25-50% lower than mesosulfuron or pinoxaden + fenoxaprop. Across the years, the addition of pyrasulfotole + bromoxynil or bicyclopyrone + bromoxynil to the grass herbicides did not increase or reduce roughstalk bluegrass control. If not effectively controlled roughstalk bluegrass reduced winter wheat yields by 33-54% compared with the non-treated control. From our research mesosulfuron applied EPOS to roughstalk bluegrass has provided the most consistent control. Pinoxaden + fenoxaprop have also provided good control and would allow for frost seeding red clover. Fall applications have provided good initial control, but spring emergence of roughstalk bluegrass can lead to some escapes at wheat harvest. Later spring herbicide applications should be avoided due to poorer control and yield reductions due to roughstalk bluegrass competition.

The Surfactants from Other Foliar Herbicide Applications on Sensitive Soybean Can Increase the Expression of Dicamba Off-Target Movement Injury. Matthew Osterholt*[1], Bryan G. Young[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, Brookston, IN (130)

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. 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 greenhouse experiment was conducted to determine if formulation adjuvants within formulated herbicides influence soybean sensitivity to dicamba along with evaluating the influence of the application timing on the interaction between foliar herbicides and their adjuvants on soybean sensitivity to dicamba. In order to simulate a dicamba exposure event, technical grade dicamba acid was dissolved in methanol, applied an increased spray height, and reduced carrier volume to dicamba-sensitive soybean at the V3 growth stage at 0.56 g ae ha^{-1}. Treatments were arranged as a two-factor factorial in a randomized complete block design with ten replications and the experiment conducted twice. Factor A consisted of water, commercially available formulations of glyphosate, glufosinate, and formulation blanks of glyphosate and glufosinate. All applications were applied at 140 L ha^{-1}. Factor B consisted of herbicide application timing (in relation to the dicamba exposure) which were 48 h before, 24 h before, 0.5 h before, 0.5 h after, 24 h after, and 48 h after. A non-treated and a dicamba applied alone were added to the treatment list for comparison. At 28 DAT, soybean treated with either glyphosate, glufosinate, glyphosate formulation blank, or the glufosinate formulation blank resulted in increased soybean injury, increased number of injured nodes, and reduced middle leaflet of the fifth trifoliate in comparison to the soybean treated with only dicamba acid a crossed all application timings. Within each application timing, there was no difference in any of the response variables between glyphosate and the glyphosate formulation blank and glufosinate and the glufosinate formulation blank indicating the surfactants within glyphosate and glufosinate are responsible for the increased soybean response. In regards to application timing, soybean treated with either glufosinate or the glufosinate formulation blank 48 h before, 24 h before, 0.5 h before, or 0.5 h after the dicamba exposure event resulted in increased soybean injury, increased number of injured nodes, and reduced middle leaflet width of the fifth trifoliate in comparison to soybean treated with either glufosinate or glufosinate formulation blank 48 h after the dicamba exposure. Soybean treated with water did not increase soybean response. Results from this study indicate that the surfactants contained in formulated glyphosate and glufosinate increase the response of sensitive soybean to dicamba exposure from off-target movement.

Effects of Fall-Planted Cereal Cover-Crop Termination Time and Method on Weed Suppression in Hemp Grown for Fiber in Michigan. Erin E. Burns*; Michigan State University, East Lansing, MI (131)

Weed control has been reported as a primary challenge in establishing hemp (*Cannabis sativa* L.) grown for grain or fiber. Knowing that no herbicides are currently labeled for use in hemp in the U.S., cultural weed management options such as the use of cover crops need to be tested for their effectiveness. To evaluate the effects of fall-planted cereal cover-crop termination time and method on weed suppression in hemp grown for fiber in Michigan a field study located in southern Michigan at the Kellogg Biological Station was planted to cereal rye (*Secale cereale* L.) in the fall of 2020. Individual plots (3.0 m x 12.2 m) were managed in the spring of 2021 with one of 10 treatments including the timing (10 days prior or at hemp planting) and type method (roller crimper or herbicide) of cover crop termination followed by the use or lack of in-season herbicide weed control. No cover crop plots were included as controls and were left no-till or tilled prior to planting. A burndown application (glyphosate + saflufenacil) was applied 38 days before planting to simulate no cover crop while glyphosate alone was applied six days before planting for early termination. A Polish fiber hemp variety, Bialobrzeskie, was planted at 53.2 kg ha^{-1} on May 20th in all plots. Hemp and weed stand counts were taken in-season and at harvest, and hemp subplots (0.25 m^2) were harvested by hand to determine yield estimates. The cereal rye was at heading (approximately Feekes 10.3) at the time of hemp planting. Herbicide termination was effective, but the roller-crimper did not successfully terminate the rye just prior to planting. Few hemp plants were found in plots where the rye had been crimped while weed pressure was very high, and those plots were considered a stand failure. Hemp dry matter yields were higher with in-season herbicide weed control compared with no herbicide in all treatment combinations except with no cover, tilled plots. Although in-season weed control numerically reduced both weed density and biomass when measured at harvest, both were highly variable and no differences were detected among treatments except the treatment combination of cover crop termination at plant via herbicide and no in season weed control had significantly more weeds than the treatment combination of no cover, no-till, and received in season weed control. The results of the first-year study showed that a cereal rye cover crop did not appear to suppress weeds without an in-season herbicide application regardless of termination timing.

Weed Pressure in Field Grown Sulfonylurea-resistant *Camelina sativa* and *Brassica napus*.
James V. Anderson*[1], Brant Bigger[1], Joseph Mettler[2], Kirk A. Howatt[2], Marisol T. Berti[2]; [1]USDA- ARS, Fargo, ND, [2]North Dakota State University, Fargo, ND (133)

Some oilseed species in the Brassicaceae family such as camelina [*Camelina sativa* (L.) Crantz] and canola (*Brassica napus* L.) can be used as rotational crops or winter cover crops to enhance delivery of ecosystem services. To evaluate weed suppression provided by sulfonylurea-resistant camelina and canola, a replicated study was conducted at the North Dakota State University (NDSU) main campus and Northwest 22 (NW22) field sites during the 2020 growing season. Field plots were set up in a complete block design including four blocks of camelina, canola, and fallow per location. Camelina or canola was seeded (18 May) in designated plots at approximately 4.92 kg ha^{-1} for camelina and 2.91 kg ha^{-1} for canola. Data was collected mid- and late-season (29 June and 22 July, respectively) for crop and weed stem count (no. m^{-2}), biomass (dwt kg m^{-2}), and nutrient content (N, P, K, S g m^{-2}), as well as final season (7 August) seed yield (g m^{-2}) for camelina and canola treated (12 June) with or without sulfonylurea. Camelina plots were treated with thifensulfuron at 6.3 g a.i. ha^{-1} with Prefer 90 (NIS) at 0.25% v/v, and canola plots were treated with thifensulfuron at 10.5 g a.i. ha^{-1} and tribenuron at 5.3 g a.i. ha^{-1} with NIS at 0.25% v/v. Compared with fallow, both camelina and canola reduced mid- and late-season weed pressure (stem count and biomass) at the NDSU field plot. At the NW22 site, weed stem counts were not different when comparing camelina and canola plots with fallow; however, biomass of weeds was reduced by camelina and canola. Herbicide application had an additive effect of reducing weed stem counts and biomass in camelina and canola plots at NDSU but was not a significant variable at NW22. Camelina and canola biomass, final seed yield, and nutrient content was significantly greater for both camelina and canola at NW22 compared with both crops at NDSU, with or without herbicide application. Although final mean seed yield of canola varied without or with herbicide application at NDSU, 129.9 ± 51.7 vs. 101.1 ± 25.3 g m^{-2} respectively, herbicide was not a significant variable for final seed yield at either location. Canola retained greater nutrient content (g m^{-2}) compared with camelina at both locations, but herbicide was not considered a significant variable for nutrient content. These results suggest that sulfonylurea-resistant camelina and canola could be good rotational options for enhancing ecosystem benefits in agriculture settings.

Evaluation of Living Mulch Species and Their Effect on Weed Pressure in Cotton.
McKenzie J. Barth*, Muthukumar V. Bagavathiannan, Hayden R. Taylor; Texas A&M University, College Station, TX (134)

Solutions to complex issues like herbicide-resistant weeds require unconventional approaches such as living mulches. Early in the growing season, cotton grows slowly and is very sensitive to competition from weeds. There is a growing need to develop non-chemical methods to suppress weeds in cotton as the number of herbicide-resistant weeds increases. An experiment was conducted at the Texas A&M University Research Farm in College Station, Texas to assess 22 living mulch species and mixes, while minimizing the competitive effect on cotton. Living mulch species were planted 3 weeks after cotton emergence and received no additional weed control throughout the growing season. Living mulch ground cover, light interception, living mulch and weed biomass, and cotton yield. Several living mulch species - alfalfa, berseem clover, flax, slender creeping red fescue, tall fescue, and zucchini - did not establish. Overall, the presence of a living mulch species was found to significantly reduce weed pressure and had a significantly greater cotton yield than the weedy check. Weed suppression potential varied across living mulch species, with Japanese millet, cowpea, and soybeans being the best performers. Cotton yield was negatively impacted by some species, such as one species mix and buckwheat. Living mulches show significant promise as another “little hammer” to combat weeds, but more research is required to better understand the potential of living mulch species and their integration into weed management programs.

Discovery of the First Glyphosate-Resistant Grass Weed in Canada. Charles M. Geddes*, Mattea M. Pittman; Agriculture and Agri-Food Canada, Lethbridge, AB, Canada (135)

Downy brome (*Bromus tectorum* L.) is a winter-annual, summer-annual, or biennial grass weed that was introduced to North America from Europe in the mid-1800s. Since then, it spread throughout most of the continent resulting in significant infestations in cropland, pastureland and ruderal areas. In the summer of 2021, a diligent agronomist noted severe lack of control of a downy brome population in a glyphosate-resistant canola (*Brassica napus* L.) field in Taber County, Alberta, following four applications of glyphosate alone. Seed was collected from the downy brome population in early July and compared with two known susceptible populations under controlled-environment in repeated glyphosate single-dose (900 g a.e. ha^{-1}) and dose-response (0, 56, 112, 225, 450, 900, 1800, 3600, 7200, and 14400 g a.e. ha^{-1}) whole-plant bioassays. The field rate of glyphosate (900 g a.e. ha^{-1}) did not cause plant mortality or visible control of the putative resistant downy brome population 21 days after treatment (DAT). The putative resistant population exhibited 10.8- to 12.0-fold, 7.8- to 8.8-fold, and 7.5- to 8.4-fold resistance to glyphosate based on plant survival, visible control, and biomass fresh weight 21 DAT, respectively, compared with two susceptible populations; thereby confirming glyphosate resistance. Further testing under controlled-environment revealed that the glyphosate-resistant downy brome population was not cross-resistant to other post-emergence herbicides. Quizalofop alone or in combination with imazamox, imazamox + bentazon, or imazamox/imazethapyr, and glufosinate mixed with either clethodim or tiafenacil resulted in =80% control of the glyphosate-resistant downy brome population based on visible control, plant survival, and biomass fresh and dry weights 21 DAT. This downy brome population represents the first glyphosate-resistant grass weed documented in Canada. Further research will focus on determining the mechanism of glyphosate resistance in the downy brome population, and understanding the full scope of this problem in southern Alberta.

Herbicide Susceptibility Survey of Watergrass (Echinochloa Spp.) in California Rice.

Whitney Brim-DeForest*, Taiyu Guan, Troy Clark; University of California, Yuba City, CA (136)

In California rice, herbicide resistance has been documented in *Echinochloa* spp. since the early 2000's. Recent reports of uncontrolled grasses, as well as possible new species or biotypes have precipitated renewed research on this genus. In August-September of 2020, 64 watergrass samples were collected from rice fields across the rice-growing region of California. The samples were representative of the *Echinochloa* spp present in California rice, but were likely resistant, as they were self-reported by growers and Pest Control Advisors: late watergrass (*Echinochloa phyllopogon*), junglerice (*E. colona*), barnyardgrass (*E. crus-galli*), and a currently unknown new biotype which is being characterized in a complimentary study. The overall objective was to determine the distribution and status of resistance to currently-registered herbicides in these species (cyhalofop, propanil, bispyribac-sodium, penoxsulam, benzobicyclon+halosulfuron, clomazone, and thiobencarb). Two known susceptible controls of late watergrass (*E. phyllopogon*) were added to the screenings as controls. Screenings took place at the Rice Experiment Station greenhouse in Biggs, CA, in the summer and fall of 2021. All formulations were tested at the 1.5 leaf stage of watergrass. Dormancy was broken for the watergrass by wet-chilling in the fridge for approximately two weeks before planting. Seeds were pre-germinated in the incubator. Pots were seeded and then thinned down to 4 plants per pot. All foliar-applied formulations (cyhalofop, propanil, and bispyribac-sodium) were applied with the label-recommended surfactants. Applications for into-the-water herbicides (granular formulations of penoxsulam, benzobicyclon+halosulfuron, clomazone, and thiobencarb) were made onto the water surface of bins that were flooded to 10 cm above the soil surface of the pots (where the watergrass was planted). All liquid herbicide treatments were applied with a cabinet track sprayer with an 8001-EVS nozzle delivering 40 gallons of spray solution per acre (at a pressure of approximately 20 psi). A flood was applied at 10 cm above the soil surface at 48 hrs after application. All herbicides were applied at standard field rates for California rice, though not at the maximum label rate for all herbicides. At 14 days after treatment, the number of living plants per pot was counted, and fresh biomass was measured (per pot) by cutting plants at the soil surface and taking the weight (per pot). Dry biomass was measured after drying the fresh weight samples down to a constant weight. Samples were classified as resistant to an herbicide if the average percent (%) dry weight control was less than that of the susceptible controls. Out of the barnyardgrass samples (31), 23 were resistant to cyhalofop (CY), 3 were resistant to propanil (PR), and 26 were resistant to bispyribac-sodium (BS). Out of the late watergrass samples (9), there were 9 CY-resistant, 5 PR-resistant, and 9 BS-resistant. For the new unknown biotype samples (22), there were 17 CY-resistant, 3 PR-resistant, and 20 BS-resistant. For the granular formulations, barnyardgrass (31 samples) had 27 that were thiobencarb resistant (TH), 24 that were benzobicyclon+halosulfuron resistant (BH), 17 that were clomazone resistant (CL), and 26 that were penoxsulam resistant (PE). Out of the late watergrass samples (9), 9 were TH-resistant, 9 were BH-resistant, 6 were CL-resistant, and 9 were PE-resistant. For the new unknown biotype samples (22), there were 20 TH-resistant, 18 BH-resistant, 11 CL-resistant, and 20 PE-resistant. The implications of this study reflect anecdotal evidence relayed by growers. *Echinochloa* spp. are becoming increasingly difficult to manage using our currently registered herbicides. For growers, this means it is increasingly difficult to plan an effective program that both controls grasses and prevents further selection for resistance.

Maverick™: A New Herbicide Premix for PRE and POST Weed Control in Corn. Lowell Sandell*[1], Garrison J. Gundy[2], John Pawlak[3], Jonathon Kohrt[4], Eric Ott[5], Chad L. Smith[6], Trevor Israel[7], Ron Estes[2]; [1]Valent USA LLC, Ashland, NE, [2]Valent USA LLC, Seymour, IL, [3]Valent USA LLC, Lansing, MI, [4]Valent USA LLC, West Des Moines, IA, [5]Valent USA LLC, Greenfield, IN, [6]Valent USA LLC, Cleveland, MS, [7]Valent USA LLC, Sioux Falls, SD (137)

Maverick™ Corn Herbicide is a new three-way premix, consisting of mesotrione, clopyralid, and pyroxasulfone, currently being developed by Valent USA LLC. Maverick Corn Herbicide has a relatively low use rate compared to many of the corn products currently available and can be applied preplant incorporated, preemergence, postemergence, or as a sequential-split application. Maverick Corn Herbicide is effective on a broad range of broadleaf and grass weed species, including problematic weeds like Palmer amaranth (*Amaranthus palmeri*), common waterhemp (*Amaranthus tuberculatus*), common lambsquarters (*Chenopodium album*), and fall panicum (*Panicum dichotomiflorum*). Field research trials conducted over the past three years with Maverick Corn Herbicide applied preemergence resulted in similar levels of weed control compared to Resicore® (Corteva Agriscience™) when applied at labelled use rates. In the same trials the addition of atrazine (840 g ai ha-1) to Maverick Corn Herbicide resulted in the same level of weed control as Acuron® (Syngenta). Maverick Corn Herbicide also controls a broad spectrum of many prevalent weeds in the Midwest when applied postemergence. The addition of atrazine and/or glyphosate can broaden the weed spectrum and improve overall efficacy of Maverick Corn Herbicide when applied to emerged weeds. Maverick Corn Herbicide is currently pending EPA registration.

Stimulating Germination and Emergence of Wild Oat (*Avena fatua*) and Volunteer Cereals.
Shaun M. Sharpe*[1], Taylor Kaye[1], Breanne D. Tidemann[2]; [1]Agriculture and Agri-Food Canada, Saskatoon, SK, Canada, [2]Agriculture and Agri-Food Canada, Lacombe, AB, Canada (138)

Wild oat is a widespread threat to spring annual crop production on the Canadian Prairies. Multiple herbicide-resistant wild oat biotypes have been identified with resistance towards Groups 1, 2, and 15 herbicides. Infesting populations are difficult to manage due to complex dormancy, a long emergence window, a long-persisting seedbank, and seed shatter corresponding to typical crop harvest timings. Management strategies for targeting the seedbank are limited. Wild oat has previously demonstrated a positive germination response to exogenously applied products such as potassium nitrate and gibberellins. Understanding the responsiveness of exogenously applied stimulants to wild oat and volunteer cereals may promote emergence at more desirable times such as pre-seeding to utilize broad-spectrum herbicides or post-harvest to utilize a killing frost. The study objective was to evaluate the suitability of applying exogenous potassium nitrate and pyroligneous acid for promoting germination and emergence of wild oat and volunteer wheat, barley, and oats. Dose response experiments were conducted in control environments in both petri dishes and pots. The wild oat biotype used was insensitive to varying concentrations of potassium nitrate. In petri dishes, concentrations of 5% or greater pyroligneous acid induced dormancy for wild oat, oat, barley, and wheat. Pyroligneous acid did enhance the emergence rate index for wild oat when applied to pots either with or without field soil. There was no impact of pyroligneous acid dose on wheat, barley, or oat emergence rate index. Results demonstrate a suitable use-pattern for stimulating emergence of wild oat from freshly mature seed with pyroligneous acid using conventional spray equipment. Additional experiments are required to determine the efficacy of this product in the field and impact of additional stimulants on its efficacy.

Investigations of Suspected Weed Resistance to XtendiMax® Herbicide with VaporGrip® Technology. Aruna V. Varanasi*, Jenny Krebel, John Willis, Jeffrey Herrmann, Chandra Aradhya; Bayer Crop Science, Chesterfield, MO (139)

The dicamba formulation XtendiMax® herbicide with VaporGrip® Technology is registered for use in dicamba-tolerant soybean and cotton by the U.S. Environmental Protection Agency (EPA) with certain conditions of registration (EPA Reg. No. 264-1210). One of these conditions includes investigation of product performance inquiries on lack of XtendiMax herbicide efficacy in the field. Weed populations suspected to have resistance in the field were sampled for testing in controlled environment. Seeds from 57 weed populations, consisting primarily of waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer) and Palmer amaranth (*Amaranthus palmeri* S. Watson), were collected from 39 counties and 11 states in 2020 and 2021 crop seasons. Whole plant bioassays were conducted in the greenhouse at a Bayer CropScience research facility in Chesterfield, Missouri to screen the populations for response to 560g ae ha^{-1} (label rate) and 1120g ae ha^{-1} of XtendiMax. All plants were treated at 7 to 10 cm height and evaluated for percent mortality and survivor injury 21 days after treatment. Results were compiled and reported to EPA. Over the two years of testing, one population each of waterhemp and Palmer amaranth had ~70% mortality at 560g ae ha^{-1}. While there were no survivors at 1120g ae ha^{-1} in the waterhemp population, Palmer amaranth population had ~7% survivors. Further testing for these populations is in progress to repeat the experiment and determine the level of sensitivity. Overall, waterhemp and Palmer amaranth sensitivity to XtendiMax varied in some populations, but there was no evidence of suspected resistance in any of the remaining populations tested. ®XtendiMax® herbicide with VaporGrip® Technology is the registered trademark of Bayer CropScience LP

Effect of Glyphosate Plus Dicamba or 2,4-D Rate and Exposure Timing on Peanut. Pratap Devkota*, Prasanna Kharel, Joseph E. Iboyi; University of Florida, Jay, FL (140)

In southeastern US, peanut is commonly grown in close proximity to Enlist cotton, soybean, or corn fields. 2,4-D choline plus glyphosate is primarily applied for weed control in Enlist system, so there is potential for herbicide drift to adjacent peanut. Field studies were conducted to evaluate the response of peanut exposure timing at 25, 50, or 75 days after planting (DAP) to various rates of newer formulation of dicamba or 2,4-D with glyphosate. Dicamba plus glyphosate was applied at 1.1 + 2.5, 4.4 + 10, 17.6 + 40, and 70.4 + 160 g ae ha^{-1}, respectively. Likewise, 2,4-D plus glyphosate was applied at 2.1 + 2.2; 8.4 + 8.8; 33.6 + 35.2; and 134.4 + 140.8 g ae ha^{-1}, respectively. Significant interaction was observed between peanut exposure timing or rate of dicamba or 2,4-D choline applied with glyphosate on peanut injury, canopy width and height, and yield reduction. Peanut injury at 4 WAT with dicamba plus glyphosate was 12% greater while exposed at 25 DAP compared to 50 DAP or later. However, peanut injury with 2,4-D plus glyphosate was in the order of 25 DAP (24%) > 50 DAP (18%) > 75 DAP (12%). There was rate response of dicamba or 2,4-D applied with glyphosate on peanut injury at 4 WAT. Peanut injury at 4WAT ranged from 10 to 44% where injury increased with the increased rates of dicamba plus glyphosate. Similar result was observed with 2,4-D plus glyphosate with the peanut injury ranging from 8 to 38%. Peanut canopy reduction (>19%) and canopy height reduction (>21%) at 4 WAT, and yield reduction (>9) was observed with dicamba plus glyphosate exposed at 25 DAP compared to 50 or 75 DAP. Similarly, peanut canopy reduction (>13%) and height reduction (>6%) was observed with 2,4-D plus glyphosate at 25 DAP compared to 75 DAP exposure timing, but there was no response on yield reduction. The dicamba plus glyphosate rate response was observed on peanut canopy, height and yield reduction and ranged from 1 to 32%, 3 to 31%, and 3 to 41%, respectively. Similarly, 2,4-D plus glyphosate rate effect on peanut canopy, height, and yield reduction ranged from 1 to 22%, 2 to 23%, and 5 to 33%, respectively. This research highlighted that drift from dicamba or 2,4-D tank-mixed with glyphosate can cause significant injury and yield reduction on peanut depending on exposure rate and peanut growth timing.

Evaluation of Dicamba Volatility Reducing Agents. Ryan D. Langemeier*[1], Rodrigo Werle[2], Katilyn J. Price[1], Livia Pereira[1], Justin T. McCaghren[1], Steve Li[1]; [1]Auburn University, Auburn, AL, [2]University of Wisconsin-Madison, Madison, WI (141)

Dicamba tolerant crops are widely planted in soybean and cotton growing regions of the United States. Dicamba is commonly tank mixed with glyphosate, but dicamba volatility may increase when tank mixed as glyphosate lowers the pH of the spray solution. Little literature is available about the comparative effectiveness of potential VRAs, and a study was designed to evaluate five different VRA active ingredients. In June 2020, field experiments were conducted in Macon county, Alabama and Columbia county, Wisconsin. The experiment was repeated in June 2021 in Macon county, Alabama. Treatments consisted of five reagent grade VRAs and one commercial foliar fertilizer product (Agripotash) tank mixed with dicamba at 560 g ae ha-1 and glyphosate at 1260 g ae ha-1, a chemical control which received no buffer, and a non-treated control. Treatments were applied to four greenhouse flats filled with soil two times for a total applied rate of 1120 and 2520 g ae ha-1 of dicamba and glyphosate at 140 L ha-1, respectively. The flats were placed inside of an open-ended low tunnels between two rows of sensitive soybeans for 48 hours. Visual injury was recorded at 14, 21, and 28 days after treatment (DAT). Soybean width and height was recorded at 28 DAT. Dicamba air concentration was sampled from every tunnel except the non-treated controls for the entire exposure period. Averaged visual injury among treated plots ranged from 2 to 28% in Alabama, and 1 to 10% in Wisconsin in 2020. Treatments with VRAs had significantly less injury at both sites relative to the non-treated control. Dicamba air concentration reductions relative to the no VRA treatment ranged from 83-96% in Alabama and 58-87% in Wisconsin across all VRAs. Our results indicate that all VRA active ingredients evaluated effectively reduce dicamba volatilization in differing environments.

Carrot Growth Response to Simulated 2,4-D and Dicamba Drift. Sushila Chaudhari*, Christopher G. Galbraith, Benjamin Phillips; Michigan State University, East Lansing, MI (142)

Despite 2,4-D or dicamba restricted-use status, record keeping requirements, and spray drift mitigation requirements, reports of off-target movement of these herbicides to sensitive crops are widespread. Injury due to sublethal doses of synthetic auxins has been demonstrated for many commodities. At present very limited in-depth research has been conducted to examine the potential impact of dicamba and 2,4-D drift on specialty crops such as carrot, onion, or celery. Therefore, the main goal for this project is to assess the potential impact on carrot growth from reduced rates of 2,4-D (Embed) and dicamba (Xtendimax) herbicide formulations that may be encountered in off-target movement. Two studies were conducted at MSU greenhouse, East Lansing, MI during 2021. Soil type was muck soil (32% Sand, 14% Silt, 3% Clay, 51% OM, and pH 7.1) and collected from grower field from Hudsonville, MI. Soil was autoclaved before use. Treatment design was RCBD with five replicates. Blaines (processing variety) carrot seeds (10-12) were planted on 7/30/2021 in 1.5 qt pots and thinned to 4 carrots/pot on 8/18/2021. In first study, herbicide application made at 2 to 3 leaf-stage, and rate applied 1/2500x and 1/500x of Xtendimax, Embed alone or with RoundupPM. There were no injury symptoms showed on plants; therefore, a second application made at 4 to 5 leaf-stage. Plants treated with 1/500x and 1/2500x were treated again with 1/100x and 1/10x rates, respectively. So, total rate applied in two runs 1/80x (1/100x + 1/500x) and 1/10x (1/10x + 1/2500x). Hereafter, rates are referred as 1/80x and 1/10x. In second study, application was made at 2 to 3 lf-stage and rate applied at 1/100x and 1/500x. Data were subjected to ANOVA using SAS 9.4 PROC GLIMMIX and means separated using Fisher's Protected LSD test (P=0.05). Injury symptoms ranged from complete plant death at 1/10x rate of Embed plus Roundup to leaf twisting/strapping and dark color spots/stunting of carrot roots from other herbicide rates. At 7 and 14 DAT, 1/10x rate of Embed alone, Embed plus Roundup, and Xtendimax plus Roundup caused higher injury than 1/80x rate. However, this difference was not reported at 1/100x and 1/500x rate of these herbicides. The negative impact of Embed, Xtendimax and Roundup drift on carrot root length, root biomass, and shoot biomass was reported from 1/10x and 1/80x rates as compared to 1/100 and 1/500x rates. Based on these results, both dicamba and 2,4-D drift can cause injury to carrot (foliage and root). Higher injury was observed from 2,4-D than dicamba. The level of injury from both of these herbicides increased when applied in combination with glyphosate. The level of injury depends on the drift rate. Higher drift rate caused more injury than lower drift rate. Therefore, proper consideration should be given to use of auxin herbicides in close proximity to carrot production fields and making applications under environmental conditions that are not conducive to off-target spray movement.

Effect of Steam and Cover-crop Treatments on Yield and Management of Weeds in Tomato. Tabata R. Oliveira*[1], Isabel Schlegel Werle[2], Sydney M. Stockwell[1], Shaun Broderick[1], Clay Cheroni[1], Te-Ming (Paul) Tseng[1]; [1]Mississippi State University, Mississippi State, MS, [2]University of Arkansas, Fayetteville, AR (143)

It is a well-known fact that weeds decrease crop productivity. Some weeds commonly trigger losses in specific crops, such as yellow and purple nutsedge, large crabgrass, and Palmer amaranth, which appear more often in tomatoes. The use of plastic mulching and cover crops are known to contribute to weed suppression in numerous crops. The objective of the study was to determine the effects of soil steaming and plastic mulching on weed control in tomato. The effects of cover crop treatments on weed suppression were also studied. The trials were conducted at the Mississippi State University Truck Crops Experiment Station at Crystal Springs, Mississippi. The experiment was laid out in a randomized complete, sub-plot block design with six treatments and replicated in three high-tunnels. Each plot was planted with a mixture of yellow nutsedge, large crabgrass, and Palmer amaranth at a coverage of 20 plants m-2 for each weed species. Two days after sowing the weed seeds, the soil surface in each plot was exposed to steaming until soil temperature reached 82°C for 0, 5, and 20 min, in separate treatments. Collected data included weed cover, plant height, and fruit yield. Weed coverage of 55% was observed in 0 min of soil steaming in non-mulched treatment, in which the primary weed was yellow nutsedge. Soil steaming for 5- or 20-minutes increased tomato plant height by 5 cm, and plants mulched with plastic grew 8 cm taller than those not-mulched. The use of mulching contributed to a yield increase in tomato by 46%, while 5 and 20 min of soil steaming improved the total yield by 57%. The results of this study suggest that steaming the soil for just 5 min promotes the suppression of Palmer amaranth and large crabgrass, while yellow nutsedge coverage was reduced by about 50%. Weed densities varied by cover crop mixtures, with Palmer amaranth showing the largest decrease of 75% compared to fallow fields. In contrast, the rye+vetch+radish cover treatment increased Palmer amaranth density. Mulching and soil steaming increased fruit yield by 46 and 57%, respectively. Incorporating cover crops with soil steaming is an effective method for managing weeds, particularly in organic or high tunnel production where producers are not available to spray herbicides, and options are limited for weed control. In addition to weed control, soil steaming encourages reduced or no-till practices, which are more sustainable.

Gelatinous Nostoc Suppression in Container Nursery Roadways Using Glufosinate, Copper Hydroxide, or Copper Ethanolamine. Joe C. Neal*, Christopher D. Harlow; North Carolina State University, Raleigh, NC (145)

Nostoc is a cyanobacterium that produces slippery, gelatinous mats that are a slipping hazard for nursery workers on gravel and walkways in container nurseries. In previous research we have demonstrated that most herbicides labeled for use in container nurseries do not control *Nostoc*. Previous research has suggested that copper hydroxide or copper ethanolamine may provide control of *Nostoc*. Furthermore, recent grower observations suggest that glufosinate could provide suppression. Experiments were established to evaluate and compare glufosinate, copper hydroxide, and copper ethanolamine for *Nostoc* control in container nursery roadways. Glufosinate (Finale XL) efficacy was evaluated at two commercial nurseries in central North Carolina. Both sites received daily overhead irrigation. Treatments at the first site were Finale XL at 1.5 lb ai/A with or without 0.25% nonionic spray adjuvant (Hook), surfactant alone, and a nontreated control. Surfactant alone did not affect *Nostoc* cover at the first test site, so that treatment was omitted at the second site and copper ethanolamine (Captain XLR) at 3 gal/A was added for comparison. In a separate experiment at the first site, Captain XLR at 3 or 6 gal/A, and copper hydroxide (Kalmor) at 5 or 10 lb/A were compared. In all experiments, treatments were applied twice at 3-week intervals with a CO_2-pressurized sprayer equipped with two 8008 TeeJet flat-fan nozzles and calibrated to deliver 50 GPA. Kalmor was applied at 100 GPA using two passes with the sprayer. Treatments were arranged in randomized complete block designs with five replicates. First applications were made on July 21st at site 1 and August 4th at site 2. A nontreated section of roadway was left between all treated plots to aid in treatment evaluations and to assess when nursery operations were disturbing the test areas. Percent ground cover of *Nostoc* was visually assessed before applications and approximately every 2 to 3 weeks until 6 weeks after the 2nd applications. Percent reduction in *Nostoc* cover from pre-treatment assessment was calculated. Captain XLR and Kalmor reduced *Nostoc* cover by 80 to 85%; there was no difference between doses or products. Finale XL at 1.5 ai/A applied twice at 21-day intervals reduced *Nostoc* cover by 82 to 91% and was not significantly different from Captain XLR at 3 gal/A. The addition of spray adjuvant did not improve Finale XL efficacy but did reduce foaming of the spray solution. These data demonstrate the effectiveness of three possible treatment options for control of *Nostoc* in nursery roadways and walkways.

Italian Ryegrass (*Lolium perenne* spp. *multiflorum*) with Electric Current in Hazelnut Orchards. James R S Wirth, Rafael M. Pedroso, Marcelo L. Moretti*; Oregon State University, Corvallis, OR (146)

Italian ryegrass populations in Oregon have evolved resistance to multiple herbicides mode-of-action, and resistant- and multiple-resistant biotypes dominate the landscape. Non-chemical methods of weed control are needed to manage these biotypes. The present work evaluated Italian ryegrass response to an electric weeder (EH-30 Thor, Zasso™, Zug, Switzerland) in two hazelnut orchards in Oregon in the spring and summer of 2021. Both fields were infested with Italian ryegrass, which was 30-45 cm in height and was in the vegetative stage at treatment. The electricity was produced by a 24 kW generator powered by a tractor power-take-off and connected to a transformer. Electric current was applied directly to the target plant foliage using two sets of applicators measuring 0.6 by 0.5 m. Electric current was applied at 5 or 9 kV at five speeds of operation (0.4; 0.8; 1.6; 3.2 and 6.4 km h^{-1}), and a nontreated control was included. Plant wilting was observed within minutes after treatment. Control ranged from 30 to 60% at three days and increased up to 28 DAT. Greater control (70-95%) was observed with 9 kV at 28 DAT at a speed of 3.2 km h^{-1}. Conversely, 40% control was achieved at a similar speed with 5 kV. Electric current reduces Italian ryegrass shoot dry weight by 47-93% and inflorescence dry weight by 61-93% by 56 DAT. In both experiments, Italian ryegrass regrowth was observed, even at low-speed applications, suggesting that sequential applications may be required. No injury was observed to hazelnut trees in these experiments, but dry matter combustion was frequent in higher voltage treatments. These data suggest that electric currents effectively control ryegrass and reduce seed production. This research project is ongoing.

Weed Management Strategies in Organic Carrot. Maryse L. Leblanc*; Institut de recherche et de développement en agroenvironnement, St-bruno-de-montarville, QC, Canada (148)

Organic field crop producers are seeking to diversify their cropping systems by introducing vegetables into their crop rotation, such as carrots used in processing or fresh market. Few of them manage to grow carrots on a large scale because the mandatory hand weeding is very time-consuming and requires great attention and meticulousness. Carrot seedlings that emerge are tiny and can't stand in competition with weeds. Mechanical in-row weeding is more problematic because few tools can get very close to carrot seedlings without damaging them. It was hypothesized that mechanical weeding in carrots could be as close as 2,5 cm to seedlings without yield loss. A two-year study was conducted at the Organic Agriculture Innovation Platform at St-Bruno-de-Montarville, Québec, Canada to evaluate mechanical weed control implements used at 2,5, 5 and 7,5 cm from the crop row. Carrots were grown on ridges spaced 76 cm apart. The mechanical weed control treatments were carried out when the carrot was at the 1 and 4 leaf stages. The weeding implements were a cage weeder and a DUO-Parallelogram used with cut-away discs and angle blades, double cut-away discs or a two-wheel hoe. The experiment was arranged in a split plot design with 4 replicates where weeding tools were assigned to the main plot (4 rows) and tool distances from the crop row to the subplots including a hand weeding control. After the two mechanical weeding treatments, carrots were hand weeded regularly until harvest to avoid any competition with weeds. In the first year, carrot yield was 20 % lower when double discs were used. In the second experimental year, there was no significant difference between tools, but the cage weeder tended to have lower yield than other implements. For both years, yields were similar between tool distances from the crop row, indicating that carrots could be cultivated as close as 2,5 cm with no yield loss. Carrots were no more misshapen or forked when mechanical hoeing was done closer to the row than the manual weed control. Weeding at 2,5 cm from the row left on average 45 % less weeds than at 7,5 cm, reducing labor time for manual weeding on the row.

Sensitivity of Eggplant (*Solanum melongena*), Cucumber (*Cucumis sativus*), and Snap Bean (*Phaseolus vulgaris*) to Sub-lethal Rates of Dicamba. Thierry E. Besancon*[1], Lynn M. Sosnoskie[2], Maggie H. Wasacz[3], Mark VanGessel[4]; [1]Rutgers University, Chatsworth, NJ, [2]Cornell University, Geneva, NY, [3]Rutgers University, Wall Township, NJ, [4]University of Delaware, Georgetown, DE (149)

Dicamba is a synthetic auxin herbicide that provides effective control of various herbicide-resistant weeds. Following the introduction of dicamba-resistant soybeans in 2017, concerns regarding dicamba off-target movement onto sensitive vegetable crops has steadily increased. Field experiments were conducted in New Jersey, New York, and Delaware to evaluate snap bean, eggplant, and cucumber yield and morphological response to sub-lethal rates of dicamba. These crops were grown in the field and exposed to dicamba at 0, 0.056, 0.011, 0.56, 1.12, 2.24 g ae ha^{-1}, representing 0, 1/10,000, 1/5,000, 1/1,000, 1/500, and 1/250 of the maximum recommended label rate for soybean application (560 g ae ha^{-1}), respectively. Herbicide applications were made either at the early vegetative or early reproductive stages. Plants were visually evaluated for injury and measured for height, vine length, and yield. No visual injury, yield reduction, or vine length differences among treatments were detected for cucumber. Higher visual injury at 0.56 g ha^{-1} (13-60%) and above were noted on eggplant compared to the nontreated control. However, this did not translate to significant yield reduction. Sub-lethal dicamba rates caused high visual injury and yield reduction in snap bean at both locations. When averaged across application timings, 'Caprice' snap bean yield was reduced to 63% of the nontreated control yield when 2.24 g ha^{-1} of dicamba was applied in New Jersey. In New York, dicamba at 2.24 g ha^{-1} reduced 'Huntington' snap bean yield 85% and 96% when applied at the vegetative and reproductive stages, respectively, compared to untreated plants.

Integration of Cover Crops, Rhizobacteria and Organic Herbicide Applications in Organic Tomato Production. Harrison T. Campbell*, Matthew A. Cutulle; Clemson University, Charleston, SC (150)

ompetition with weeds is one of the factors limiting organic tomato production. To improve weed management, multiple techniques need to be combined in an Integrated Weed Management (IWM) approach. New Organic Materials Review Institute (OMRI) certified products, such as caprylic acid derived herbicides and rhizobacteria mixtures, offer both directed weed control and increased tomato vigor that can enhance crop competition versus weeds. Traditional cover crops such as cereal rye and crimson clover enhance soil health as well as suppress weeds. Research was conducted to evaluate the impact of combining cover crops, rhizobacteria treatments, and organic herbicides on weed control and tomato yield in an organic production system. The experiment was conducted as a randomized complete block split plot. The treatments were structured with main plot factors as cover crop treatment (cereal rye (Secale cereale), crimson clover (Trifolium incarnatum), or no cover crop) by organic herbicide treatment (Capric + Caprylic acid at 18% v/v or no herbicide treatment). Each main plot was split into sub plots either containing Rhizobacteria treatment (SC27 rhizobacteria product) or not. The cover crops were planted October 20th, 2020, at the Clemson student organic farm in Clemson, SC and terminated April 16th, 2021. Tomato transplants of the cultivar "New Girl" were transplanted on May 17th, 2021, and the organic herbicide applications were made May 26th, 2021. Tomato fruits were harvested, counted, and weighed by sub plot on July 7th, 14th, 22nd, and finally on August 2nd, 2021. With and without organic herbicide treatment, the addition of SC27 increased average fruit yield across all cover crop treatments. Non herbicide treated plots plus SC27 in the crimson clover cover crop plots saw the highest average fruit weight across all treatments. Organic tomato producers would benefit from incorporating a cover crop regime into their production practices and utilizing beneficial mycorrhizal organisms to increase tomato yields. Organic tomato growers could also potentially benefit from the use of an organic capric and caprylic acid herbicide application to control troublesome weeds and decrease weed competition, provided weeds are treated early in the growth cycle and reasonable effort is made to ensure the herbicide does not contact tomato foliage.

IR-4: Weed Control Projects Update - Food Crops. Roger B. Batts*[1], Jerry Baron[2], Venkat Pedibhotla[2]; [1]IR-4 Project, Fremont, NC, [2]IR-4 Project, Raleigh, NC (151)

IR-4 Weed Science Update – Food Crops. Roger B. Batts, Jerry Baron, Venkat Pedibhotla. IR-4 Project, NC State University, Raleigh, NC Residue projects Data submitted by IR-4 led to just under 650 new uses in 2021, as of early December. This is above the number of new supported uses in 2020 but less than the five year average. Of these, 75 uses were for herbicides (clopyralid, quizalofop, MCPA) in many different specialty crops, crop groups or subgroups (*Brassica carinata*, bulb onion subgroup, caneberry subgroup, cottonseed subgroup, pennycress, pome fruit, sunflower subgroup, vining small fruit subgroup and wheatgrass). IR-4 submitted six data petitions for herbicides and plant growth regulators to EPA in 2021. Products included tribenuron, fluazifop, rimsulfuron, fomesafen, glufosinate, and trinexapac. These submissions could potentially lead to more than 225 new uses. Thirteen new herbicide magnitude-of-residue studies began in 2021, which could result in more than 45 new uses. Ten new residue studies will begin in 2022. Product Performance projects Generating Product Performance (efficacy and crop safety) data to support registration of pest management tools in specialty crops continues to be an important and expanding part of the IR-4 annual research plan. This data is often required by registrants and/or states to complete the registration process. The number of on-going herbicide Product Performance studies in 2021 was twenty-five (66 individual trials), with eleven of them beginning in 2021. The 2022 field research plan for herbicides and plant growth regulators includes nineteen (>60 individual trials) continuing or new Product Performance studies. Integrated Solutions projects IR-4's Integrated Solutions (IS) Program is structured to assist specialty crop growers outside of the traditional single product/single crop residue and product performance research. IS research efforts focus on four areas, 1) pest problems without solutions, 2) resistance management, 3) products for organic production and 4) pesticide residue mitigation. In 2021, there were five active IS projects with herbicides and plant growth regulators (11 individual trials), most of which will continue in 2022. Five new weed control IS studies will begin in 2022 (>20 individual trials), including rice, hemp, hops, stone fruit, pear and date palm.

Evaluation of Cover Crops in Anaerobic Soil Disinfestation for Weed Management in Organic Tomato Production. Gursewak Singh*, Matthew A. Cutulle; Clemson University, Charleston, SC (152)

Increasing production challenges in organic farming, such as weed control, have greatly affected US growers' market share and profitability. Yellow nutsedge (*Cyperus esculentus* L. CYPES) is the most problematic weed in plasticulture vegetable production. Weed control options are limited for organic production. Anaerobic soil disinfestation (ASD) is a novel approach that generates restricted anaerobic conditions in the topsoil layer for a limited period. ASD was developed initially to manage soilborne diseases, but it has also demonstrated the ability to control weed species. The input of labile carbon to promote microbially-driven anaerobic conditions in moist soils covered with polyethylene mulch is the basis of ASD. Cover crops have the potential to be utilized as ASD carbon sources. Field study was conducted in the fall 2020 to determine the efficacy of warm season cover crops used as carbon sources for ASD and their role in weed management utilizing randomized complete block design with four replications. The treatment design consists of a factorial with 4 cover crops (sorghum-sudangrass, sun hemp, both or none) by 2 ASD treatments (sealed or non-sealed). The goal is to identify the most effective treatment which maintains organic tomato yield while managing weeds. Cover crops were grown for 75 days and then incorporated into the soil and sealed with totally impermeable film (TIF) clear mulch. Plastic sealed plots were airtight completely and unsealed were punctured with circular holes on the top and sides of beds. An initial irrigation of 5 cm was applied and afterwards plots were irrigated based on moisture and redox potential readings. ASD performed for 4 weeks. Tomato plants (Galahad F1) were transplanted by 2 ft spacing. Weed counts were estimated by counting emerged weeds on whole bed (0, 30, 60 DAT). Weeds were categorized as yellow nutsedge and grasses. The tomato crop was harvested weekly/biweekly based on the crop harvest condition. All incorporated cover crop treatments generated moderate to higher anaerobic conditions (0 - 150 mV). The cover crop and plastic sealing had a significant influence on yellow nutsedge and grass weeds counts 0 DAT ($P < 0.05$). No significant differences in terms of plant growth, vigor and tomato marketable yields were observed between all the treatments. No phytotoxicity was observed on tomato plants after ASD. The result of this study suggests that the warm season cover crops have potential to serve as a carbon source for ASD in tomato production, however more work is needed to improve consistency and further elucidate the working mechanism for weeds management.

Evaluating an Integrated Weed Management Approach for Flumioxazin on Potato in North Dakota. Harlene M. Hatterman-Valenti*, Collin Auwarter; North Dakota State University, Fargo, ND (153)

Most nightshade species are alternate hosts for insects and diseases that attack potatoes such as Colorado potato beetle and late blight. Eastern black nightshade (*Solanum ptycanthum* Dun.) has been recognized by growers as one of their worst weed problems. This may be due to grower reliance on metribuzin for broadleaf weed management in potato, and the resulting poor nightshade control as well as the reluctance to use herbicides that can control nightshade in a rotational crop because they also have high carryover potential. Flumioxazin provides excellent control of nightshades but has been shown to also cause injury to potato. To alleviate most of the injury to potato, the label restricts use in potato to only 25 states that includes North Dakota. The label further restricts and limits the herbicide application timing and states: "Many weather-related factors, including high wind, splashing or heavy rains or cool conditions at or near potato emergence, may result in potato injury in fields treated with Chateau EZ Herbicide. On occasion this has resulted in a delay in maturity. Understand and accept these risks before using Chateau EZ Herbicide." Furthermore, the label states: "In areas with historically higher amounts of rainfall during the time of preemergence herbicide applications, including the Red River Valley, Minnesota and North Dakota, the requirement for 2 inches of settled soil is critical to avoid crop injury." The objective was to determine the effect of integrated weed management strategies with flumioxazin on weed control and potato safety under irrigation. Treatments included the labeled use rate and half that rate at three application timings: two days after planting (DAP) and no hilling, after regular hilling (9 DAP), hilling 2 DAP and then applying, and then various application timings of flumioxazin and the combination product of metribuzin + metolachlor along with a standard of only metribuzin + metolachlor 9 DAP. Results indicated that all treatments provided similar excellent control of broadleaf annual weeds. Plots treated with 0.5X or 1X flumioxazin after an early hilling had the greatest total and marketable yields but this was only greater than one other treatment. Plots treated with 1X flumioxazin after an early hilling or 0.5X flumioxazin after early hilling followed by 0.5X metribuzin + metolachlor after regular hilling had the greatest percentage of marketable tubers but this also was only greater than a different single treatment. None of the treatments caused visible potato injury, which was attributed to the lack of rainfall prior to the initiation of irrigation. Future research will include varying irrigation applications following the flumioxazin applications to ensure evaluation of crop safety with the flumioxazin application timings.

Evaluation of Goosegrass and Creeping Bentgrass Response to Combinations of Topramezone and Chlorothalonil. John M. Peppers*[1], Matthew T. Elmore[2], Shawn Askew[1]; [1]Virginia Tech, Blacksburg, VA, [2]Rutgers University, New Brunswick, NJ (155)

Topramezone is regularly applied to cool-season turfgrass to control warm-season grassy weeds such as goosegrass *(Eleusine indica*). Due to the partial tolerance of creeping bentgrass (*Agrostis stolonifera*), topramezone is commonly applied as part of a low dose, frequent application program. Throughout the summer months, topramezone is typically applied concurrently with many other agrochemicals. Turfgrass managers often mix multiple crop protection products to reduce application costs and traffic to turfgrass. These mixtures can sometimes be antagonistic to one or more products in the mixture. This phenomenon has been well studied with respect to mixtures of multiple herbicides but few studies have evaluated how fungicide + herbicide mixtures may affect weed control efficacy. The objective of this research was to evaluate goosegrass control with two topramezone rates applied alone and in combination with a standard rate of two chlorothalonil formulations. A field study was conducted in the summer of 2021 at the Virginia Tech Campus Golf Course to evaluate goosegrass control with topramezone alone and in combination with two formulations of chlorothalonil. Topramezone was applied alone at 3.68 and 6.13 g ai/ha. Both rates of topramezone were also applied with 7356 g ai/ha of Daconil Weatherstik and Daconil Action. All treatments contained methylated seed oil adjuvant at 0.5% v/v and were applied on July 21 with a reapplication on August 6. Goosegrass was between 3-5 tillers (Figure 1) at study initiation. Two greenhouse studies were also conducted to evaluating goosegrass response to a broader range of topramezone rates (0, 1, 2, 4 and 6 g ai/ha) either alone or in combination with chlorothalonil (Daconil Weatherstik) applied at 7356 g ai/ha. A second application was made 3 weeks after the initial treatment (WAIT). In the field study, topramezone controlled goosegrass 70-81% at 6 WAIT and control was reduced at least 28% when either chlorothalonil formulation was added to the mixture. Chlorothalonil formulations did not significantly differ in their impact on goosegrass control at any assessment. In controlled environment studies, chlorothalonil admixture required 28% more topramezone to control goosegrass 50% compared to topramezone alone with a concomitant 67% increase in topramezone rate to achieve 50% biomass reduction. These studies suggest that chlorothalonil should not be mixed with topramezone when used for goosegrass control.

Guardrail Bareground Applications in KY: Spring or Fall Timing? Joe Omielan*; University of Kentucky, Lexington, KY (156)

For highway safety guardrails need to be kept clear of visual obstructions. Usually that means maintaining a vegetation free zone underneath them. Applications of broad spectrum residual herbicides in the spring have become the mainstay for bareground maintenance operations in combination with a broad spectrum post-emergent herbicide like glyphosate. Fall applications using newer less soil mobile chemistries may have some advantages. The trial was established beside cable barrier near Morehead, KY in 2021. In the spring 24 treatments with 3 replications were arranged in a randomized complete block design and in the fall 8 treatments in common were established as well. Treatments were applied at 233 L/ha onto 1.2 m by 3.2 m plots on May 27 and Sept 14, 2021. All common treatments included Roundup ProMax or Rodeo (glyphosate) for post-emergence control. Our long-term standard treatment has been the older, high use rate herbicide Sahara (diuron + imazapyr). Newer low use rate products and combinations tested included Escort (metsulfuron), Milestone (aminopyralid), Method (aminocyclopyrachlor), Perspective (aminocyclopyrachlor + chlorsulfuron), Viewpoint (aminocyclopyrachlor + metsulfuron + imazapyr), and Esplanade (indaziflam). Visual % bareground ratings were taken 63 (7/29), 110 (9/14), and 158 (11/1) days after treatment (DAT) for the spring application and 48 (11/1) DAT for the fall application. Data were analyzed using ARM software and treatment means were compared using Fisher's LSD at p = 0.05. All common treatments with residual herbicides had more bareground than the control at the first assessment date at both times of application. Further assessments in 2022 will be done to evaluate these management options.

Leafy Spurge, E*uphorbia esula L.,* Management with Pyraflufen-ethyl Plus 2,4-D Ester.
Phillip Westra*[1], Jim T. Daniel[2], Milo Lewis[3], James Adams[4]; [1]Colorado State University, Fort Collins, CO, [2]Daniel Ag Consulting, Keenesburg, CO, [3]Nichino America, Whiteface, TX, [4]Nichino America, Wilmington, DE (157)

ABSTRACT Leafy spurge (*Euphorbia esula L)* management with pyraflufen-ethyl plus 2,4-D ester. Philip Westra, Colorado State University, Fort Collins, CO; Jim Daniel, Daniel Ag Consulting, Keenesburg, CO; Milo Lewis, Nichino America, Inc., Whiteface, TX; and James Adams, Nichino America, Inc., Wilmington, DE. Leafy spurge is an invasive, perennial noxious weed found in most US states and southern Canada. It was introduced into Minnesota in 1890 in a bushel of oat seed from Russia. Biocontrol agents have had modest success in controlling this weed, although sometimes additional biocontrol agent releases are required. It is one of the major US introduced noxious perennial weeds which received multi-year federal support for research on its biology, ecology, and control. It has been present in Colorado since the early 1970s. An experiment was conducted NW of Fort Collins, CO near Curtis Lake to evaluate control of leafy spurge, *E. esula L.,* with three yearly applications of pyraflufen-ethyl (Venue), 0.0053 lb/A + 2,4-D ester, 1.0 lbae/A with 1.0 % V/V COC and aminocyclopyrachlor (Method 240 SL), 0.25 lb ae/A, with 1.0% V/V COC. Annual foliar applications were made to the same plots for 3 consecutive years in early to mid-June each year with a 10 ft backpack boom equipped with 11002 nozzles delivering 20 gpa. Treatments were replicated three times in a randomized complete block design. Visual percent control evaluations taken in the fall of each year and 3.5 years after the first application were used to monitor leafy spurge control and native grass response over time. Both control strategies provided over 90% leafy spurge control. Aminocyclopyrachlor had 60% phytotoxicity in the form of stunting and stand thinning of native perennial grasses while no grass phytotoxicity was observed from the pyraflufen-ethyl + 2,4-D treatment.

Some Invasive Weeds in Coastal Forests of British Colombia, Scotch Broom (*Cytisus scoparius* L. Link). Raj Prasad*; Emeritus Scientist/Professor, Victoria/bc, BC, Canada (159)

SOME INVASIVE WEEDS IN COASTAL FORESTS OF BRITISH COLUMBIA , SCOTCH BROOM (*Cytisus scoparius* L. Link). Raj Prasad (Retired Scientist, Pacific Forest Research Centre, Victoria, BC.) The leguminous shrubs , Scotch broom and gorse (*Ulex europeus* L) are two exotic weeds which pose a serious threat to forested and other landscapes in British Columbia(BC). Scotchbroom was introduced to this province in 1850 by Captain Walter Grant as seeds planted in Sooke near Victoria from where it has expanded its range, now occupying forests, roadsides, hydro right-of-ways and other disturbed areas up to Kootenay Lake in the anteriors of the province. By producing a large number of seeds and seed banks for over 30 years, its ability to photosynthesize in winters, its capacity to fix nitrogen, its rapid vertical,spatial growth, and the absence of parasites and predators, it outcompetes the economic conifers species(*Douglas-fir Pseudotsuga menziesci* Franco) and reduces their productivity. Experiments designed to measure its competitiveness on reduction of the crop growth of Grand-fir seedlings was co-related to blocking the infiltration of photosynthetically active radiation(PAR) and by intense competition of space, nutrients and water from the soil as cutting down the scotch broom numbers improved the growth of the crop seedlings. Also a bio-agent (*Fusarium tumidum*,Sherb) used in the greenhouse killed many Scotch broom plants.

Plant Back Restrictions: What Do They Really Mean? William J. Chism[1], Kelly Tindall*[2]; [1]US EPA, Point Of Rocks, MD, [2]US EPA, Washington, DC (162)

The Environmental Protection Agency recently became aware of misperceptions about the purpose for plant-back intervals (PBI), or plant-back restrictions, on pesticide labels and uncertainty why PBIs are not better described in regards to "cover crops." In many cases, end users believe that PBIs are on labels to inform concerns over phytotoxicity to the planted crop following a pesticide application. However, PBIs usually exist to inform the amount of time needed for residues from a previous pesticide application to have degraded such that there are no risks of concern in respect to human dietary exposure because residues could be in the next crop or animal which will contribute to dietary exposure which may require establishing a tolerance. This poster describes how PBIs relate to cover crops versus rotational crops. For instance, if a "cover crop" is harvested for human consumption or grazed by or harvested and fed to livestock that will be consumed by humans, the Agency considers the "cover crop" to be a rotational crop because it would have potential risks associated with dietary exposure. Because of the potential dietary exposure, PBIs are imposed as a mandatory requirement on labels. PBIs may be imposed as label requirements for any pesticide type, not just herbicides. However, if a "cover crop" is not harvested for human consumption or is not grazed by or fed to livestock that will be consumed by humans (e.g., planted for erosion control) then there is no risk associated with dietary exposure. When a "cover crop" has no dietary exposure, end users can conduct bioassays to assess phytotoxicity concerns to determine if crop injury will occur if the cover crop is planted prior to the PBI on the label. This poster will also provide additional information about the Agency's data requirements for establishing PBIs.

Virginia Weed Identification Clinic Summary. Wykle C. Greene*, Michael L. Flessner, Kara Pittman, Shawn Askew; Virginia Tech, Blacksburg, VA (164)

The Virginia weed clinic is a service offered to farmers and homeowners throughout the Commonwealth of Virginia which allows physical weed samples to be submitted through local extension agents for identification and control recommendations. Since 2015, there has been an average of 143 weed samples submitted to the weed identification per year. Samples have been identified from 82 localities through ought the Commonwealth, including counties, independent cities, and agencies such as the Virginia Department of Agriculture and Consumer Services. The most common weed species submitted to the weed identification clinic was tall fescue (*Lolium arundinaceum (Schreb.)*. The most common setting for weed species collected were pastures and hayfields. York county submitted the most samples to the weed identification clinic. The Virginia Weed Identification Clinic offers a valuable resource to producers, homeowners and various other stakeholders throughout the Commonwealth of Virginia. Engagement with extension agents through the weed clinic has helped to strengthen the Virginia cooperative extension network.

Dicamba Injury in Kentucky: A Comparison of the 2017 and 2021 Growing Seasons. Travis Legleiter*; University of Kentucky, Princeton, KY (165)

The University of Kentucky Extension Weed Science program conducted surveys of University of Kentucky County Extension Agents in 2017 and 2021. The surveys were conducted in 2017 following the commercialization of the dicamba-tolerant soybean system and approval of over-the-top applications of dicamba formulations. In 2021 the same survey was distributed again to county Agents after two major revisions of the labels of dicamba formulations approved for application to dicamba-tolerant soybean. Both surveys were distributed in the months of July and August of each given year following the majority of dicamba applications in the state of Kentucky. Agents were instructed to respond to survey questions based on their knowledge within their given county and within the current growing season. The primary questions on the survey related to the number of non-dicamba tolerant soybean and tobacco acres that were impacted by off-target dicamba movement. Surveys in 2017 indicated that approximately 26,000 acres of soybean were impacted, whereas in 2021 survey results indicated that approximately 27,000 acres of soybean were impacted. Tobacco acres that were injured by dicamba increased between 2017 and 2021 from 62 to 185 acres, indicating a major impact on one of Kentucky's high value commodities. In a similar trend, the number of reports of dicamba damage to commercial vegetable growers and homeowners increased over the five-year span. These results indicate that despite major label changes and increased restrictions placed on dicamba formulations, that dicamba injury to sensitive cropping systems is still occurring in Kentucky.

Addressing Citizen Concerns About Glyphosate Use in Puerto Rico. Wilfredo Robles*; University of Puerto Rico, Mayagüez, Corozal, PR (166)

Worldwide concerns on health safety have been raised due a recent classification of glyphosate as a “probably carcinogenic to humans” substance. The decision made by the International Agency for Research on Cancer (IARC) has exacerbated citizen debate regarding glyphosate use and its safety for human health. Despite final determinations by IARC, glyphosate continues to be a registered herbicide by EPA as it continues to meet regulatory compliance. While ongoing debates have continued, in Puerto Rico many citizen organizations have raised this issue and request the ban of glyphosate for weed control on rights-of-way. Several bills have been considered by the house of representatives and the senate to target the prohibition of glyphosate. It is recognized that there is existing misinformation related to the use of herbicides amongst citizens which suggests that education is key to address this issue. Therefore, educational activities such as seminars related to herbicides along with newspaper articles, and magazines have been conducted to strengthen public knowledge. Moreover, conducting case studies related to glyphosate along with active participation at public hearings at the house and the senate have provided an opportunity to respond citizen concerns and therefore address this issue. As a result, many bills related to the use of glyphosate have either been rejected or put on hold. Currently, glyphosate is still the most widely use herbicide in Puerto Rico.

Cross-resistance to Photosystem II Inhibitors Observed in Target Site Resistant But Not in Non-target Site Resistant Common Ragweed (*Ambrosia artemisiifolia*). Martin Laforest*[1], Marie-Josee Simard[2], Sydney Meloche[3], Lydia Maheux[4], Francois Tardif[5], Eric Page[6]; [1]AAC-AAFC, St-jean-sur-richelieu, QC, Canada, [2]Agriculture and Agri-Food Canada, Saint-jean-sur-richelieu, QC, Canada, [3]Agriculture and Agri-Food Canada, Harrow, ON, Canada, [4]Agriculture and Agri-Food Canada, St-jean-sur-richelieu, QC, Canada, [5]University of Guelph, Guelph, ON, Canada, [6]Agriculture and Agri-Food Canada, Harrow, Canada (171)

The full spectrum of herbicide resistance in a weed can vary according to the mechanistic basis and can not be implied from the selective pressure. *Ambrosia atemisiifolia* is an important weed species of horticultural crops that has developed resistance to linuron based on either target site or non target site resistance mechanisms. The objective of the study is to characterise the cross resistance to metribuzin of linuron selected biotypes of *A. artemisiifolia* with target site and non target site and determine its genetic basis. Crosses were made between two types of linuron resistant biotype and linuron susceptible biotypes and the progeny was further backcrossed with susceptible plants to BC3 to determine their response to both herbicides compared to parental lines. The target site based linuron resistant biotype was cross resistant to metribuzin and resistance to both herbicides was maintained at the same level in the BC3 line. In contrast, the linuron selected biotype with non target site resistance mechanism was not cross resistant to metribuzin. In addition, the BC3 lines deriving from the non target site resistant parents had very low-level resistance. While the target site resistance trait is maintained through multiple crosses, non target site-based resistance would be lost over time when selection is absent or insufficient to retain all genes involved in resistance as a complex trait. This would imply *A. artemisiifolia* biotypes with different mechanisms would need to be managed differently over time.

Import of Palmer Amaranth (*Amaranthus palmeri* S. Wats.) Seed with Sweet Potato (*Ipomea batatas*) Slips. Eric Page*; Agriculture and Agri-Food Canada, Harrow, ON, Canada (172)

Palmer amaranth is one of the most economically important and widespread weeds of arable land in the United States. Although no populations are currently known to exist in Canada, its distribution has expanded northward such that it is present in many of the States bordering Canada and multiple pathways exist for its introduction. In this study we report on the transport of viable Palmer amaranth seed on imported sweet potato slips. A reproductive pair of Palmer amaranth seedlings were identified from soil accompanying imported sweet potato slips in 2018. Identification was confirmed using species specific single nucleotide polymorphisms.

Competition Between Bird's Rape and Canola in Unmanaged Field Borders: Year 1. Marie-Josee Simard*[1], Martin Laforest[2], Sara Martin[3], Lydia Maheux[1]; [1]Agriculture and Agri-Food Canada, Saint-jean-sur-richelieu, QC, Canada, [2]Agriculture and Agri-Food Canada, St-jean-sur-richelieu, QC, Canada, [3]Agriculture and Agri-Food Canada, Ottawa, ON, Canada (174)

The most widely cultivated species of canola, *Brassica napus*, can form volunteer populations in subsequent crops as well as transient feral populations in field borders and roadsides. Bird's rape mustard (*Brassica rapa*) is closely related to *Brassica napus* and can form fertile hybrids with the crop that can backcross with parental lines. If both species grow together in a crop or a field border, the weedy *B. rapa* should show higher fitness and progressively replace domesticated *B. napus*. Meanwhile, hybrids and backcrossed plants will also be formed. To document this process, both species were grown in unmanaged plots for three years. The experimental design was implemented twice (in 2019 and 2021) and included two *B. napus* cultivars, two wild *B. rapa* populations and a *B. rapa* cultivar. These populations were grown either isolated or with another cultivar/population (50% density). A total of 12 combinations were replicated four times. Phenological stages were noted each week and biomass as well as seed production was evaluated at maturity. Statistical analyses included mixed ANOVA models. *B. napus* plants produced more biomass and bigger seeds than *B. rapa*, regardless of treatment combination. In general, the number of seeds produced was equivalent between crop plants and weeds and reduced in crop/weed combinations. There results indicate that if *B. napus* plants grow in a field border they can present equal fitness to *B. rapa* at the end of the growing season.

Sterile Pollen Technique as a Novel Weed Management Tool. Wenzhuo Wu*[1], Mohsen B. Mesgaran[2]; [1]University of California, Davis, CA, [2]UC Davis, Davis, CA (175)

The overall goal is to examine the possibility of using sterile pollen to disrupt seed production in dioecious weeds in a similar way to the Insect Sterile Technique (IST). Using dioecious Palmer amaranth (Amaranthus palmeri) as a model system, I hypothesize that seed production in this weed can be reduced by pollinating with irradiated and sterile pollen. The objectives are to 1) determine optimal irradiation dose for pollen sterilization and 2) pollen storage conditions for large scale application. Male and female plants were planted and isolated in separate greenhouses when they reached the flowering stage. The fresh and mature pollen were collected and irradiated with gamma ray from Cesium-137 at dosages of 0,100, 200, 300, 400 and 500 Gy. Irradiated and untreated pollen were immediately used for two experiments: hand-pollination and pollen viability study. For hand-pollination study, each dosage had six treatments with five replications. On each female plant, six lateral inflorescences of similar size were selected, which received 1) no pollen, 2) only non-irradiated pollen, 3) only irradiated pollen, 4) non-irradiated pollen after irradiated pollen, and 5) irradiated pollen after non-irradiated pollen. The inflorescences were bagged immediately after pollination. The sixth inflorescence was not bagged to allow for 6) open pollination. Flower number and seed number were measured after harvesting. Pollen viability was assessed using 2,5-diphenyl monotetrazolium bromide (MTT) on irradiated pollen immediately after irradiation and after one week, 1 month, 3 months, 6 months and one year storage under -80, -20, 4, and 20 ^{o}C respectively. Results showed 300 Gy is the most effective irradiation dose and -80 ^{o}C is the optimal temperature to maintain the viability of irradiated pollen. In addition, as applying small volumes of pure pollen under real field conditions is difficult, it therefore needs to be diluted with inert materials and delivered as an easy-to-release formulation for large scale applications. Future work will be determining an ideal dry dilute at a most effective mixed ratio for large scale application and finding the optimal frequency of sterile pollen application. This method can be extended to control multiple weed species (broad-spectrum weed control), where sterile pollen from multiple weed species can be mixed and released in a single application. Furthermore, the sterile pollen technique can be particularly helpful for managing herbicide resistant weeds that have withstood in-season control and ready to produce seeds.

Utilizing RNA Sequence Transcriptome Analysis to Identify Genes Involved in Conferring Clopyralid Resistance in Ambrosia Artemisiifolia (Common Ragweed). Nash D. Hart*[1], Erin E. Burns[2], Eric L. Patterson[2]; [1]Michigan State University, Durand, MI, [2]Michigan State University, East Lansing, MI (176)

Ambrosia artemisiifolia (common ragweed) is a globally distributed, difficult to control weed species that can cause extensive crop yield reductions unless appropriately managed. Clopyralid is a synthetic auxin herbicide commonly used to control *A. artemisiifolia* and other weeds in the Asteraceae family. In 2018, a population of *A. artemisiifolia* was discovered in a Michigan Christmas tree farm that is highly resistant to clopyralid, surviving at clopyralid doses thirty-two times the recommended field use rate. Chemical weed control is a mainstay in most agricultural systems and herbicide resistance threatens its effectiveness; therefore, it is essential to understand the mechanism of resistance that allows weed species to become resistant to herbicides. To this end, we have begun investigating potential resistance mechanisms in this clopyralid resistant *A. artemisiifolia* population using RNA-seq. As no well-curated genome or transcriptome currently exists for this species, we first built a reference transcriptome de novo using Trinity and reads from the susceptible population. Next, we aligned all reads from one resistant and one susceptible population using the program HISAT2. We identified all assembled Aux/IAA annotated transcripts using BLAST and manually screened the read alignments for polymorphisms (SNPs, InDels, etc.) that distinguished resistant from susceptible individuals. We specifically evaluated the sequence motif known as "the degron" which has previously been shown to be involved in target site resistance (TSR) to other auxinic herbicides including 2,4-D and dicamba in other dicot species. We also performed a whole transcriptome differential expression analysis to identify resistance mechanisms that involve changing gene expression (i.e. non-TSR and target site over-expression). Lastly, we performed a Gene Ontology (GO) enrichment analysis on the RNA-seq differential expression data to identify global differences in the transcriptomes of these two populations. After searching the entire genome there were fifteen transcripts containing the Aux/IAA degron sequence. Six out of the fifteen transcripts containing the sequence contained a polymorphism. Zero of the transcripts had a significant polymorphism that correlated perfectly with the resistant phenotype. Differential expressional analysis highlighted 536 genes that were significantly differentially expressed, with 179 being overexpressed in the resistant population and 357 being overexpressed in the susceptible. Out of the 536 genes, there were 241 genes that had a log fold change of greater than two or less than negative two, interestingly 201 genes were overexpressed in the susceptible population, and only 40 genes overexpressed in the resistant population. Within the 241 genes, there are many genes of interest that directly relate to the auxin pathway, such as auxin response and ABC transporter genes, as well as genes associated with non-target site resistance, such as cytochrome P450s. The GO enrichment analysis discovered 12 overexpressed terms including GTPase binding and intracellular transport processes and 13 underexpressed GO terms including carboxylic acid metabolism. Ultimately, understanding clopyralid resistance in *A. artemisiifolia* and the potential for cross resistance to other auxinic herbicides is of critical importance for continued agricultural productivity in the North Central region as technologies like Enlist, Xtend, and XtendFlex soybean become more common.

Palmer Amaranth (*Amaranthus palmeri*) Seed Germination Under Simulated Lunar and Martian Magnetic Fields and Microgravity. Aniruddha Maity*, Anton Classen, Dipankar Sen, Alma Fernandez, Aart J. Verhhoef, Alexei Sokolov, Muthukumar V. Bagavathiannan; Texas A&M University, College Station, TX (177)

Space research has been exploring the potential of plant growth in outer space. Other than various adversities such as anhydrous, anoxic conditions and galactic cosmic rays, altered magnetic field as well as gravity are considered as two major detriments for plant growth in space. Plants that have the ability to withstand these adverse conditions can be particularly useful as a food source during extended manned space missions. Palmer amaranth (*Amaranthus palmeri*) can be edible and is shown to be highly adaptive to extreme stress conditions on earth. We hypothesize that these traits may allow them to adapt to the harsh extra-terrestrial conditions, especially in the Lunar and Martian environments. To this effect, we exposed Palmer amaranth seeds in both dry and wet conditions to simulated magnetic fields of Moon, ranging from 6 nano Tesla (nT) to 313 nT; and Mars, ranging from 1,000 nT or 1 μT to 1.5 μT, besides the zero (0 μT), low (15 μT), normal (50 μT), and high (100 and 150 μT) terrestrial magnetic fields, using a standard 3-D Helmholtz coil. In a separate experiment, Palmer amaranth seeds were exposed to no or microgravity using a standard clinostat. Significantly more seeds germinated with greater seedling vigor in response to Martian magnetic field (1,000 nT), especially when treated dry and also under microgravity than control. These preliminary results suggest that Palmer amaranth may show adaptability to outer space. Results require further investigation.

Effect of Cereal Rye Cover Crop and Narrow Row Soybean on Waterhemp in a Corn-Soybean Rotation Over Two Years. Ramawatar Yadav*, Prashant Jha, Alexis L. Meadows, Austin H. Schleich, Avery J. Bennett; Iowa State University, Ames, IA (179)

Multi-tactic weed management strategies are required to manage multiple herbicide-resistant (MHR) waterhemp (*Amaranthus tuberculatus* [Moq.] J.D. Sauer) populations across the Midwestern U.S. Therefore, field experiments were conducted to design multi-tactic strategies using cereal rye cover crop and narrow-row soybean in conjunction with effective corn herbicide programs (HP). Effects of cereal rye cover crop and soybean row spacing was tested in soybean in 2020 under two levels of *A. tuberculatus* seed inputs, which resulted from the previous year's corn. In 2019 corn, a marginal herbicide program (MHP) comprising of two sites-of-action herbicides and an aggressive herbicide program (AHP) comprising of three sites-of-action herbicides were used to establish two levels of *A. tuberculatus* seed inputs. In 2020, cereal rye cover crop was terminated at the time of soybean planting. Soybean was planted in narrow (38 cm) vs. wide (76 cm) rows. In 2021, the effect of previous year's cereal rye cover crop and soybean row spacing was tested in the following corn with the same corn HP. In 2019, *A. tuberculatus* produced 93,000 seeds m^{-2} in the plots treated with MHP compared with 9,300 seeds m^{-2} in the plots treated with AHP. In 2020, cover crop or narrow-row soybean alone reduced *A. tuberculatus* density by at least 13% compared with the no cover crop or wide-row soybean. Cumulatively, cover crop and narrow-row soybean reduced *A. tuberculatus* density and seed production by =40% compared with no cover crop and wide-row soybean. In 2021 corn, MHP plots had 80% higher *A. tuberculatus* density than AHP plots. Furthermore, MHP plots, which included cover crop and narrow-row soybean in 2020, had a 40% higher *A. tuberculatus* density in 2021 than plots with no cover crop and wide-row soybean; however, this difference was not evident in AHP plots. These results indicate that waterhemp should be managed aggressively in corn with multiple effective herbicide sites of action to prevent seed bank inputs. Additionally, cultural strategies such as cereal rye cover crop and reduced row spacing should be incorporated in the soybean phase of the rotation to mitigate the herbicide-resistant *A. tuberculatus* seed bank at a cropping systems level.

Light Up the Seeds: Influence of Red and Far-Red Light on Palmer Amaranth Seed Dormancy. Sarah E. Kezar*, Shuyang Zhen, Muthukumar V. Bagavathiannan; Texas A&M University, College Station, TX (180)

Seed dormancy is a critical determinant of weed species persistence in the soil seedbank, and dormancy regulation governs the proportion of germinable seedbank. Dormancy of the freshly produced seed is influenced by the genetics of the mother plant and the maternal environmental conditions in which seeds develop. Among the various environmental factors, the ratio between red (R) and far-red (FR) lights is known to alter seed dormancy in plants. In this research, we investigated seed dormancy dynamics of Palmer amaranth (*Amaranthus palmeri*), a troublesome herbicide-resistant weed in cotton production, in response to light quality differences. The treatment included eight levels of light quality: R light, FR light, R light followed by FR light, FR light followed by R light, a high R:FR ratio, low R:FR ratio, natural light, and dark condition. Each of these treatments were implemented for six different durations: 5-second pulse, 30 seconds, 1 minute, 5 minutes, 10 minutes, and 30 minutes. An aluminum-frame chamber was designed and built with mounted R and FR light bars and controls to implement the treatments. The reflectance in µmol $m^{-2}s^{-1}nm^{-1}$ was measured with a spectroradiometer to standardize light intensity within the chamber area. The experiment was conducted in a cotton field infested with a naturally occurring Palmer amaranth population at Texas A&M Research Farm near College Station, TX. The light chamber was moved to the field and powered using an electric generator. At the time of the experiment (Sep 2021), Palmer amaranth plants were at mid-to late-reproductive maturity; the region of inflorescences containing brown or black seeds were tagged before treatment. The treatments were implemented at dusk after sunset, and the treated inflorescences were harvested 21 days after treatment, dried, and threshed. Subsequently, a germination test was conducted in an incubation chamber with a 30/25 C day/night temperature regime and 12-hour photoperiod. Seed germination was observed every 4 days for 21 days. Results indicated that both immature and mature seed on the mother plant were significantly influenced by light quality, light duration, and the interaction of the two factors. Seed responded to very brief flashes of light, or a very low fluence response (VLFR), was exhibited with the 5-second treatment duration impacting phytochromes. Activation by exposure to FR and R-FR reversibility is consistent with VLFR as the quantity of Pfr established by a subsequent FR is sufficient to promote germination. From this preliminary study, we found that experienced maternal light environment and stage of weed seed maturation strongly affected weed seed germination and dormancy response to R/FR exposure. In agreeance with the literature, this study supports the concept that high R/FR rations may establish high proportions of phytochrome in the Pfr form. Which is important for germination of dark-imbibed seeds. Future research will investigate practical options for large-scale field treatments and their efficacy. Findings could be used for manipulating seed dormancy and impacting seedbank dynamics of Palmer amaranth, which can serve as an additional tool in the weed management toolbox for this troublesome species.

Residual Weed Population Shifts in Saskatchewan - 1976 to 2021. Julia Y. Leeson*, Shane Hladun; Agriculture and Agri-Food Canada, Saskatoon, SK, Canada (181)

The comparison of the relative abundance of weeds in Saskatchewan in 2019 and 2021 with results from previous provincial surveys enables the identification of shifts in species ranks and relative abundance. In 2019 and 2021, a total of 2277 fields of spring wheat, barley, durum, oat, canola, flax, mustard, soybean, lentil, pea and chickpea were surveyed. These fields were selected using a stratified random sampling procedure based on ecodistricts. In each field, weeds were counted in 20 quadrats (50 by 50 cm) in late summer. Weed data are summarized using a relative abundance index based on frequency, field uniformity and density. The results from the 2019/2021 survey are compared to results from surveys of 2242 fields in 2014/15, 2046 fields in 2003, 1178 fields in 1995, 1149 fields in 1986 and 4423 fields in 1976-1979. The two most recent surveys had years with widely varying weather conditions, being dry in 2021 and wet in 2014. As in all previous surveys, green foxtail (*Setaria viridis* (L.) P. Beauv.) was the most abundant weed in 2019/21. However, for the first time, volunteer canola (*Brassica napus* L.) ranked second, displacing wild oats (*Avena fatua* L.) and wild buckwheat (*Fallopia convolvulus* (L.) Á.Löve) to third and fourth, respectively. Eleven species have been ranked amongst the top 25 most abundant species in each survey. Black medic (*Medicago lupulina* L.) appeared in the top 25 for the first time in the most recent survey after steadily increasing since 1995. Round-leaved mallow (*Malva pusilla* Sm.) and canola have also continued to steadily increase in recent surveys, despite varying weather conditions. Spiny annual sow-thistle (*Sonchus asper* (L.) Hill) and barnyard grass species (*Echinochloa* spp.) have also increased since the 1970's; however, there was little change in relative abundance between the most recent surveys. Low cudweed (*Gnaphalium uliginosum* L.), false cleavers (*Galium spurium* L.), northern willowherb (*Epilobium ciliatum* Raf.), broad-leaved plantain (*Plantago major* L.) and foxtail barley (*Hordeum jubatum* L.) show an overall trend of increasing abundance since the 1970's; however, these species had lower relative abundances during the most recent drier survey years than during the wetter 2014-15 survey. Volunteer lentil (*Lens culinaris* Medik.), wheat (*Triticum* spp.) and kochia (*Bassia scoparia* (L.) A.J.Scott) have also increased since the 1970's, but had lower relative abundances in the wet 2014/15 survey. Several species have declined in relative abundance since the first surveys including: rose (*Rosa* spp.), bluebur (*Lappula squarrosa* (Retz.) Dumort.), cow cockle (*Vaccaria hispanica* (Mill.) Rauschert), Persian darnel (*Lolium persicum* Boiss. & Hohen. ex Boiss.), prostrate pigweed (*Amaranthus blitoides* S. Watson), flixweed (*Descurainia sophia* (L.) Webb ex Prantl), night-flowering catchfly (*Silene noctiflora* L.), hemp-nettle (*Galeopsis tetrahit* L.), redroot pigweed (*Amaranthus retroflexus* L.), Russian thistle (*Salsola tragus* L.) and pale smartweed (*Persicaria lapathifolia* (L.) Delarbre). All of these species had been previously identified as declining, except hemp-nettle.

Prospective Modeling of Weed Community Responses to Herbicide Programs Based on Species Population Dynamics. Fernando H. Oreja, Matthew Inman, David L. Jordan, Deepayan Bardhan, Ramon G. Leon*; North Carolina State University, Raleigh, NC (182)

Herbicide programs determine weed community, and over time community changes might make weed management more difficult. Simulations of weed population dynamics with stochastic models are useful tools to identify potential community changes that might result in best- or worst-case management scenarios. The objectives of this work were to model the population dynamics of weed species under different herbicide programs and to evaluate how those dynamics change weed community diversity over time in cotton. Lambda (i.e., population growth rate) values obtained from an eight-year long experiment were used to stochastically model and estimate weed population dynamics during a ten-year simulation, for each species present in the community and different herbicide programs. Population densities were used to obtain weed community attributes such as richness, diversity and evenness for each herbicide use scenario. The repeated use of glyphosate alone consistently and rapidly decreased diversity and evenness. Programs that incorporated more mechanisms of action were just slightly more likely to suffer the loss of weed species than programs with single or just a few herbicides. Simulations indicated that when highly competitive species were eradicated species with lower lambda could recover their populations and increase weed community diversity. However, the eradication of species with low reproductive rates reduced diversity and evenness. Thus, frequent changes in management that interrupt the repeated use of specific weed control programs, even under high herbicide intensity use (i.e., number of applications and mechanisms of action), can help maintain weed diversity in agroecosystems.

Comparative Biology of Female and Male Palmer Amaranth. Ednaldo A. Borgato*, Mithila Jugulam, Anita Dille; Kansas State University, Manhattan, KS (183)

Palmer amaranth (*Amaranthus palmeri*) is a summer annual, C4, with fast growth rate, highly prolific, and dioecious weed. In this current research, the dioecy in this species is being explored based on the hypothesis that if population ratios to more male-to-females can be shifted to reduce seed production and provide an opportunity for improved control of this weed in long term. We investigated patterns of emergence, growth and reproduction in female and male Palmer amaranth aiming to identify differences in their life cycle that could be incorporated in management decisions. An emergence study with two herbicide-susceptible populations (KS-S1 and MS-S1) and one -resistant (KS-R1) was performed in growth chambers maintained at 30 C and 16 h day length, and date of emergence was documented at the cotyledon stage. After emergence, seedlings were transferred to a greenhouse and their gender was documented upon flowering. Growing degrees days (GDD) required for germination in female and male Palmer amaranth were analyzed using a non-linear regression model across populations. In a growth study, dry biomass, days to flowering and days to anthesis of female and male plants were also documented and compared across populations. The results suggest that MS-S1 required about 500 GDD for total male emergence, whereas females required > 2000 GDD for total emergence. Populations from KS required > 2500 GDD for total emergence, but neither sex nor resistance had influence on that. MS-S1 produced biomass greater than KS-R1 and KS-S1, but no differences between female and male plants were found. In terms of reproductive aspects, inflorescence in males emerged ahead of females (protandry), but females had the pistils exposed before the anthesis of male plants (protogyny). Data suggested that different populations may need different thermal units required for germination and emergence, and that female and male plants may not necessarily display different requirements. Also, different populations may be more competitive than others, given their ability to grow. Furthermore, Palmer amaranth has characteristic that maximizes fertility, as female inflorescences emerge already receptive. Life-history can shape growth habits of populations, making it difficult to explore anticipated emergence to shift population ratios. Management decisions could incorporate knowledge of reproductive differences of female *versus* male to reduce seed production. Future research will investigate phenology of female and male Palmer amaranth for better accuracy of GDD requirements for each stage of their life cycles.

Absorption, Translocation, and Metabolism of Glufosinate in Glufosinate-Resistant Palmer Amaranth. Pamela Carvalho-Moore*[1], Jason K. Norsworthy[1], Jeong-In Hwang[1], Maria Leticia Zaccaro-Gruener[1], Tom Barber[2], Thomas Butts[1]; [1]University of Arkansas, Fayetteville, AR, [2]University of Arkansas, Lonoke, AR (185)

Glufosinate resistance in Palmer amaranth [*Amaranthus palmeri* (S.) Watson] was recently detected in accessions from Arkansas. Palmer amaranth is the first and only broadleaf weed species resistant to this herbicide, and the resistance mechanism is still unclear. Reducing the amount of herbicide reaching the target protein is among the plant mechanisms that confer resistance. Therefore, absorption, translocation, and metabolism of ^{14}C-labeled glufosinate was assessed to observe any differences between susceptible and glufosinate-resistant accessions. Seedlings of two glufosinate-resistant (Glu-R1 and Glu-R2) and two susceptible (SS1 and SS2) accessions were grown in a greenhouse at the Milo J. Shult Agricultural Research & Extension Center, Fayetteville, AR. At the 5- to 7-leaf stage, plants were treated with 656 g ha^{-1} of nonradiolabeled glufosinate. After treatment, plants were spotted with radiolabeled glufosinate at 240 000 disintegrations per minute (dpm) onto the adaxial surface of the second fully expanded leaf. Plants were harvested and sectioned (for translocation experiments). The treated leaf was washed to remove not absorbed radioactive material. Uptake and metabolism were not significantly different between the glufosinate-resistant and susceptible accessions. The resistant accessions showed 40 and 60% glufosinate absorption averages, while susceptible showed around 54%. Total metabolites ranged from 13 and 20% in the susceptible to 21 and 27% in resistant accessions. Glufosinate translocation above the treated leaf and in the roots showed no difference among accessions. Accession Glu-R1 showed a slight difference in the amount of ^{14}C-glufosinate detected in treated tissues and below treated leaf compared to the susceptible standards used. The average of ^{14}C-glufosinate encountered in the treated leaf was lower in Glu-R1 (92%) than in susceptible accessions (98%). In the section below the treated leaf, Glu-R1 showed a slightly higher amount of ^{14}C-glufosinate (2%) than the susceptible accessions (average of 1% or less). According to the data obtained, glufosinate uptake, translocation, and metabolism are not the resistance mechanisms in the glufosinate-resistant accessions evaluated in this study. Future research will investigate alterations that might be present in the target site (glutamine synthetase).

Weed Suppression by Full-season Cover Crops in Atlantic Canada. Andrew McKenzie-Gopsill*, Aaron Mills, Tandra Fraser, Judith Nyiraneza; Agriculture and Agri-Food Canada, Charlottetown, PE, Canada (187)

Cover crops are increasingly being incorporated into crop rotations as a mechanism to promote diversity and provide agroecosystem goods and services including weed suppression. Recently, cover crop mixtures have increased in popularity in an attempt to provide a greater diversity in ecological goods and services as compared to monocultures. Several recent studies, however, have failed to detect a positive effect of cover crop diversity on productivity or weed suppression. Here we assessed productivity and weed suppression in 19 cover crops seeded as monocultures and 19 mixtures of varying species composition and functional diversity (2- and 3-species mixtures) during peak flowering of full-season cover crops. Cover crop biomass production and weed suppression varied by species identity, functional diversity and species richness. As cover crop biomass and diversity increased, weed biomass dramatically declined. Highly productive forbs and grasses provided the greatest weed suppression in monoculture. Similarly, productive and even cover crop mixtures provided superior weed suppression as compared to less productive and diverse mixtures. In line with previous observations, however, mixtures were on average not more productive nor weed suppressive than the most productive monocultures. We observed that the inclusion of multiple highly productive species in a mixture increased stand evenness, productivity, weed suppression and spatiotemporal stability. Taken together our results suggest that effects of diversity on mixture productivity and weed suppression are species specific. This further demonstrates the importance of species selection in cover crop mixture design.

Survey of Herbicide-Resistant Wild Oat (*Avena fatua*) in the Lower-Saint-Laurent Region of Quebec. Sandra Flores-Mejia*[1], Firmo Sousa[1], Véronique Bélanger[1], Ayitre Akpakouma[2], Jalinets Navarro[3], Marc Tétrault[4], Yan Gosselin[4], Éric Pagé[4], Annie Marcoux[5], David Miville[5], Michel Dupuis[6], Samuel Comtois[7], Mario Handfield[8], Salah Zoghlami[9], Darrell M. Pack[10]; [1]Centre de recherche sur les grains (CÉROM), Saint-mathieu-de-beloeil, QC, Canada, [2]Ministère de l'Agriculture, des Pêcheries et de l'Alimentation (MAPAQ)., Rivière-du-loup, QC, Canada, [3]Ministère de l'Agriculture, des Pêcheries et de l'Alimentation (MAPAQ), Amqui, QC, Canada, [4]Fédération de l'Union de producteurs agricoles du Bas-Saint-Laurent (FUPABSL), Rimouski, QC, Canada, [5]Laboratoire d'expertise et de diagnostic en phytoprotection. (LEDP-MAPAQ), Quebec, QC, Canada, [6]Coordination services-conseils, Longueuil, QC, Canada, [7]Groupe PleineTerre, Napierville, QC, Canada, [8]Université du Québec à Rimouski (UQAR), Rimouski, QC, Canada, [9]Producteurs de grains du Québec (PGQ), Longueuil, QC, Canada, [10]CropLife Canada, Ottawa, ON, Canada (189)

Wild oat (*A. fatua,* AVEFA) is considered among the most damaging weeds in temperate zones worldwide. In Canada, up to 79 % of the surveyed fields in the Prairies have AVEFA and resistance to ACCase inhibitors (group 1) is present in up to 78 % of these populations. In Quebec, between 2011 and 2018 only five populations of AVEFA had been classified as resistant to group 1 (1-HR), representing 2.4 % of the total number of herbicide-resistant (HR) cases reported in the province. However, the samples are submitted on a voluntary basis and thus the presence of HR AVEFA can be underestimated, and even go seemingly unnoticed. A survey carried out in the Saguenay-Lac-Saint-Jean region showed that 35 % of the sampled populations were group 1-HR, but 17 % of the producers with 1-HR AVEFA did not suspect it. In 2020, a survey conducted in the Lower Saint-Lawrence (Bas-Saint-Laurent, BSL) region of Quebec showed that 75 % of growers noticed the presence of AVEFA in their fields and 25 % of them believe they have an HR population. However, up to that year no sample had been tested to confirm this, nor any systematic survey had been conducted. Thus, this project aims to: carry out the first inventory of the presence of 1-HR AVEFA in the BSL region; to identify the agricultural practices associated with its development; and to use collaborative methods in order to develop and adopt integrated control methods for this species. During the first year of the project, 24 farms and 66 fields were surveyed. Wild oat populations were found in 79 % of the farms and 80 % of the fields. The main crops where AVEFA was present were: wheat, oat and barley. Spring wheat was the crop with the most abundance, with an average of 206 AVEFA plants per square meter. A subsample of the surveyed fields (19/66) will be tested for herbicide resistance during the winter of 2022 via a whole-plant bioassay. Each population will be tested to three active ingredients of herbicides registered in Quebec for the control of AVEFA in cereals, belonging to each of the three classes of group 1: FOPs (fenoxaprop-ethyl), DIMs (tralkoxydim) and DENs (pinoxaden). A preliminary test realised in 2021 aimed to test five AVEFA populations of the BSL region to the same three herbicides (fenoxaprop-ethyl, tralkoxydim, pinoxaden). Due to lack of sufficient seeds, not all populations were tested to all three herbicides. The results showed that all five populations were HR to fenoxaprop-ethyl, 3/3 of the tested populations were HR to tralkoxydim and 1/1 was HR to pinoxaden. Thus, three populations were HR to fenoxaprop-ethyl and tralkoxydim and one population was HR to all three active ingredients. This is the first study to show that AVEFA is widespread in the BSL region, and that 1-HR populations are present, although its prevalence is yet to be determined.

Weed Suppression at Different Levels of Cereal Rye Biomass Production. Gustavo Camargo Silva*, Muthukumar V. Bagavathiannan; Texas A&M University, College Station, TX (190)

Cover crops have become one of the major non-chemical weed control tools in recent years. The most popular cover crop species is cereal rye, which apart from offering soil and water conservation benefits, has great potential for weed resistance management. Cereal rye suppresses weeds through several mechanisms, the main one being high biomass production. However, not every location can achieve high biomass levels, as it is influenced greatly by soil moisture and nutrient availability. In such situations, other mechanisms may play a role in weed suppression. The objective of this research was to determine whether high biomass production is an absolute requirement for weed suppression by cereal rye cover in a region where moisture is a limiting factor, and elucidate what other mechanisms may contribute to weed suppression. The study was conducted at the Texas A&M Field Research Station near College Station, TX during 2020-21. Cereal rye was planted at four seeding rates (0, 20, 40, and 80 kg ha^{-1}) and terminated at three timings (6, 4 and 2 weeks before planting cotton), totaling 12 treatments, which were arranged in a split-plot design with 4 replications. Cereal rye biomass production was determined at termination, which was carried out using glyphosate (870 g ae ha^{-1}). Cotton was planted (April 20) into the cereal rye residues with a no-till drill. Weed density and emergence pattern were assessed in the early summer. Preliminary results show that termination timing had greater influence on biomass production than seeding rate, due primarily to compensatory tillering. A critical minimum biomass production of ~2 t ha^{-1} is necessary for significant weed suppression. Further, weed suppression did not show a linear trend with biomass even at <6 t ha^{-1}, and moderate biomass (2 to 4 t ha^{-1}) can be sufficient to provide desirable weed suppression. Results suggest potential role of other mechanisms with respect to weed suppression by cereal rye. Future research will investigate the influence of cereal rye on altering soil nutrients and light quality.

Screening of Sweet Potato Varieties for Their Allelopathic Ability to Suppress Palmer Amaranth Growth in a Stair-step Structure. Varsha Varsha*[1], Isabel Schlegel Werle[2], Mark W. Shankle[3], Stephen L. Meyers[4], Te-Ming (Paul) Tseng[5]; [1]Mississippi State University, Starkville, MS, [2]University of Arkansas, Fayetteville, AR, [3]Mississippi State University, Pontotoc, MS, [4]Purdue University, West Lafayette, IN, [5]Mississippi State University, Mississippi State, MS (191)

The present study was conducted with 17 varieties of sweet potato to evaluate the allelopathic effect of sweet potato on the growth of Palmer amaranth (*Amaranthus palmeri*). The study was conducted in the Department of Plant and Soil Sciences greenhouse at Mississippi State University, MS, under controlled conditions. The experiment was carried out in a stair-step setup, and data was collected for plant height, biomass, and chlorophyll content. Palmer amaranth showed a significant height reduction in the presence of sweet potato varieties Morado, 529, Centennial, Heart-O-Gold, and Hatteras. Reduction in Palmer amaranth's height was above 80% in the presence of variety Morado at four weeks after transplantation (WAT), while the reduction was above 70% in the presence of varieties 529 and Centennial, compared to Palmer amaranth control. Reduction in chlorophyll content at 4 WAT was above 50% in the presence of varieties 529, Centennial, and Hatteras. Varieties Hatteras, Evangeline, Covington, 529, and Centennial drastically reduced Palmer amaranth dry biomass. Results of the ANOVA for weekly plant height showed that the variation among the sweet potato varieties is significant, thus suggesting different sweet potato varieties have different effects on Palmer amaranth growth. The present findings show that sweet potato varieties Centennial, Evangeline, Hatteras, 529, and Morado suppressed the Palmer amaranth growth and can be considered for further allelopathic studies to identify the cause and pathway responsible for weed growth suppression.

Effects of Cover Crops on Weed Emergence Across Three Soybean Producing Regions.
Sarah A. Chu*[1], Lauren M. Lazaro[1], Gabrielle LaBiche[1], Muthukumar V. Bagavathiannan[2], Michael L. Flessner[3], Ramon G. Leon[4], Steven Brian Mirsky[5], Mark VanGessel[6]; [1]Louisiana State University, Baton Rouge, LA, [2]Texas A&M University, College Station, TX, [3]Virginia Tech, Blacksburg, VA, [4]North Carolina State University, Raleigh, NC, [5]USDA- ARS, Beltsville, MD, [6]University of Delaware, Georgetown, DE (193)

Cover crops are a vital component of integrated management systems as they increase soil organic matter, cycle nutrients, improve soil structure, prevent the loss of sediment and nutrients, alter soil temperature, increase water infiltration with residue retention, and suppress weeds. Cover crops can suppress weeds directly and indirectly, as cover crops can fill an ecological niche, compete for resources, and create a physical or chemical barrier. Cover crop benefits are linked to biomass accumulation, which can be influenced by climate, soil, and management. The objective of this experiment was to assess the impact of a cereal rye (*Secale cereale*) cover crop biomass on weed suppression and soybean (*Glycine max*) yield, with the hypothesis that an increase in cereal rye biomass will result in an increase in weed suppression and soybean yield. The split plot experiment was conducted in Louisiana (LA), Delaware (DE), Maryland (MD), Virgina (VA), and Texas (TX) in 2021 and treatments included the presence and absence of cereal rye. The following season weed species varied based on location and soybean was managed based on local recommendations. Average cereal rye biomass at termination was 104 g m^{-2}, 189 g m^{-2}, 270 g m^{-2}, 458 g m^{-2}, and 624 g m^{-2} for LA, MD, DE, VA, and TX, respectively. Soybean yield did not differ between treatments with or without cover crops for VA, DE, and LA. Weed biomass collected at the end of the growing season was not significant between treatments for LA, DE, and MD. Weed biomass accumulation was dependent on treatment and the type of weed species present in TX. Weed biomass in VA was 78% greater in cover crop plots compared to plots without cover crops, which may be due to low cover crop biomass accumulation. Cover crop effectiveness at suppressing weeds is variable based on location.

Oral 01. Agronomic Crops

Can a Rapid Assay be Developed to Confirm Glufosinate Resistance Before Widespread Evolution? Eric A. Jones*, Robert Austin, Diego J. Contreras, Charlie W. Cahoon, Katherine M. Jennings, Ramon G. Leon, Wesley Everman, Jeffrey Dunne; North Carolina State University, Raleigh, NC (197)

Glufosinate resistance has evolved in only five species and resistance has yet to evolve widespread. Glufosinate is one of the remaining effective postemergence herbicides, thus reliance on this herbicide for weed control is likely to increase and select for resistant weeds. Putative glufosinate-resistant weeds are subjected to dose-response assays or molecular sequencing to determine if resistance has evolved. The current assays to confirm herbicide resistance can be time and labor intensive (dose-response) or require a technical skillset (molecular sequencing). Since glufosinate inhibits chlorophyll production and incurs rapid necrosis, we propose a new, rapid assay utilizing spectral reflectance to confirm glufosinate resistance. Leaf discs were excised from a glufosinate-resistant and –susceptible cotton variety and placed into a 24-well plate containing different concentrations (0-10 mM) of glufosinate for 48 hours. A multispectral sensor captured images from the red, blue, green, and rededge wavebands after the 48 hour incubation period. The green leaf index (red and green wavebands) was utilized to determine the green ratios of the treated leaf discs. Clear differences of spectral reflectance was observed between the leaf discs of the glufosinate-resistant and susceptible cotton varieties at the highest concentration tested for all wavebands and the green leaf index. Leaf discs from two additional glufosinate-resistant and –susceptible cotton were subjected to a similar assay with the discriminating glufosinate 10 mM concentration. Clear differences again were observed between the leaf discs of glufosinate-resistant and –susceptible cotton varieties for all wavebands. The leaf discs of the cotton varieties were inseparable with the green leaf index. The results provide a basis for rapidly detecting glufosinate-resistant plants via spectral reflectance. Future research will need to determine the glufosinate concentration thresholds for weeds that evolve resistance.

Ectopic Expression of a Rice Triketone Dioxygenase Gene Confers Mesotrione Tolerance in Soybean. Sarah Berger*, Shunhong Dai, Nikolaos Georgelis, Mohamed Bedair, Yun-Jeong Hong, Qungang Qi, Clayton Larue, Bikram Sitoula, Wei Huang, Brian Krebel, Michael Shepard, Wen Su, Jiaxin Dong, Thomas Slewinski, Christine Ellis, Agoston Jerga, Marguerite Varagona; Bayer Crop Science, Chesterfield, MO (199)

Development of new herbicide tolerance traits provides growers with additional options to effectively manage weeds in an increasingly challenging environment. Mesotrione, a triketone herbicide, is a selective, pre- and post-emergence herbicide used primarily in corn production to control weeds via inhibition of hydroxyphenylpyruvate dioxygenase (HPPD). Recently, the rice *HIS1* gene was identified. This gene is responsible for the native tolerance to several selective triketone herbicides. In transformed soybean, ectopic expression of a codon-optimized version of the *HIS1* gene (*TDO)* resulted in commercial-level tolerance to mesotrione. In *TDO* transgenic soybean plants, mesotrione is rapidly and locally oxidized into non-inhibitory metabolites in leaf tissues directly exposed to the herbicide and further converted into compounds similar to known classes of plant secondary metabolites. This metabolism prevents mesotrione movement to vulnerable emerging leaves, while protecting the function of HPPD and carotenoid biosynthesis- ultimately providing crop tolerance to mesotrione. *TDO* transgenic soybean described here provides growers with a new option to effectively manage weeds in soybean as part of a comprehensive integrated weed management system. This trait also has the potential to be adapted to other mesotrione-sensitive crops such as cotton.

Herbicide Tolerance Traits for PPO-inhibitor Herbicides in Field Crops. Clayton Larue*, Christine Ellis, Shirley Guo, Qungang Qi, Rita Varagona, James Roberts; Bayer Crop Science, Chesterfield, MO (200)

Protoporphyrinogen IX oxidase (PPO)-inhibiting herbicides are an agronomically important class of herbicides that act by inhibiting the PPO enzyme, a key enzyme in the biosynthetic pathways of chlorophyll and heme. The PPO enzyme is conserved across plant species and thus many important crop plants are sensitive to PPO-inhibitor herbicides. The development of a biotech trait to provide tolerance to these herbicides in key crops brings value to weed control programs. In this presentation, the discovery of a unique microbial PPO enzyme and development of a biotech herbicide tolerance trait utilizing this microbial PPO will be reviewed. The potential application of this trait in weed control packages will be discussed.

Rapidicil™, A New and Unique PPO Inhibiting Herbicide for Burndown Program. John Pawlak*[1], Lowell Sandell[2], Yoshimi Fujino[3], Yoshinao Sada[4], Yoshinobu Jin[4], Akihiro Tomita[3]; [1]Valent USA LLC, Lansing, MI, [2]Valent USA LLC, Ashland, NE, [3]Sumitomo Chemical Co., Ltd., Tokyo, Japan, [4]Sumitomo Chemical Co., Ltd., Hyogo, Japan (201)

Rapidicil™ (epyrifenacil) is a low use rate PPO inhibiting herbicide in the N-Phenyl-imides subgroup. Rapidicil™ has unique characteristics for a PPO inhibiting herbicide including translocation via the phloem and xylem. Rapidicil™ has activity on a large rage of broadleaf weeds at 20 g ai/ha and is active on annual grasses at rates of 20 to 40 g ai/ha. Rapidicil™, alone and in combination with flumioxazin, offers postemergence control of three biotypes of PPO resistant Palmer amaranth (Amaranthus palmeri) and waterhemp (Amaranthus rudis). Postemergence efficacy of Rapidicil™ is enhanced with by the addition of crop oil concentrate and/or non-ionic surfactant. Rapidicil™ first EPA registration is expected in 2024 for preplant burndown uses in soybean, corn, wheat and canola. Rapidicil™ will be positioned as a component of a burndown program primarily with glyphosate plus dicamba to enhance speed of control and aid in resistance management.

Rapidicil™, a New Systemic PPO Herbicide for Broad-spectrum Weed Control. Yoshinobu Jin*[1], Yoshinao Sada[1], Masashi Hikosaka[1], Kunio Ido[1], John Pawlak[2]; [1]Sumitomo Chemical Co. Ltd., Hyogo, Japan, [2]Valent USA LLC, Lansing, MI (202)

Rapidicil™ (epyrifenacil) is a novel phenyluracil PPO-inhibitor herbicide invented by Sumitomo Chemical Co., Ltd. and is non-selectively effective on both broadleaf and grass weeds by foliar application. It shows herbicide efficacy quickly at low use rate (10 - 40g ai ha-1) and acts systemically. In comparison to other PPO-inhibitor herbicides, the biggest feature of Rapidicil™ is having a strong foliar activity on grass weeds. In a pharmacokinetics study, its systemic action was revealed to be mediated by phloem mobility of its acid form hydrolyzed in plant. Rapidicil™, exposed to soybean plants as vapor arisen from treated soil for 48 hours in plastic containers, did not cause any phytotoxicity including necrotic symptom and malformation in new leaves on soybean plants unlike the case of dicamba dimethylamine salt. Rapidicil™ showed strong herbicidal efficacy on target-site resistant (TSR) biotypes of Palmer amaranth at both *in vitro* and *in vivo* level compared to other PPO herbicides (flumioxazin, fomesafen or lactofen). In conclusion, Rapidicil™ is a broad-spectrum herbicide with ideal characteristics (low dose rate, quick and systemic action, less persistence in soil and less volatility) as a burndown herbicide and promising as a powerful tool for resistance management.

Confirmation of Resistance in Smallflower Umbrella Sedge (*Cyperus difformis*) to an ALS Inhibiting Herbicide and its Control with Florpyrauxifen-benzyl. Seshadri S. Reddy*[1], David Ouse[1], Craig Alford[2], Vijay K. Choudhary[3]; [1]Corteva Agriscience, Indianapolis, IN, [2]Corteva Agriscience, Johnston, IA, [3]ICAR–Directorate of Weed Research, Jabalpur, Mp, India (203)

Smallflower umbrella sedge is a commonly found problematic weed in direct seeded rice in India. Acetolactate synthase (ALS) inhibiting herbicide bispyribac-sodium is frequently used to control weeds in rice, but recently rice growers have reported poor control of smallflower umbrella sedge with this herbicide. Hence an extensive survey was carried out in two rice growing states Chhattisgarh and Kerala and collected 53 putative bispyribac-sodium resistant (BR) biotypes. Pot experiments were conducted for two seasons to confirm the resistance and to test the efficacy of newly developed synthetic auxin herbicide florpyrauxifen-benzyl (Rinskor™ active) on putative BR biotypes. Dose-response studies revealed that bispyribac-sodium is no longer a promising herbicide to control the sedge. From 53 biotypes, 17 biotypes survived 1X rate (25 g ai ha^{-1}) of bispyribac-sodium. The amount of bispyribac-sodium required to provide 50% control (ED_{50}) across all BR biotypes ranged from 19 to >200 g ha^{-1} whereas it was 10 g ha^{-1} in susceptible biotype. This suggests 2 to >20 folds resistance in BR biotypes. Higher levels of ALS enzyme activity in BR biotypes compared to susceptible biotype suggested altered target site as mechanism of resistance to bispyribac-sodium. This study confirmed first case of evolved resistance in smallflower umbrella sedge for bispyribac-sodium in India. However, all these BR biotypes were completely controlled by florpyrauxifen-benzyl at the suggested field use rate (31.25 g ha^{-1}).

Target-Site And Nontarget Pathways of ALS Inhibitor Resistance in *Cyperus difformis*.
Alex R. Ceseski*, Kassim Al-Khatib; University of California, Davis, CA (204)

Smallflower umbrella sedge (*Cyperus difformis* L.), is a pernicious weed of rice worldwide. Smallflower populations have been confirmed to be resistant to acetolactase synthase (ALS) inhibitors throughout the California rice region. Screening many smallflower populations for cross-resistance to ALS inhibitors has revealed six major resistance patterns, suggesting multiple mechanisms of resistance. Studies of non-target resistance mechanisms *in planta* via malathion-mediated cytochrome-P450 (P450) inhibition, and *in vitro* using liquid chromatography and mass spectrometry (LC-MS), revealed diverse pathways of increased ALS inhibitor metabolism. However, results suggested target-site alteration may also be a mechanism of resistance for smallflower populations under study. Identification of target-site ALS inhibitor resistance in smallflower populations that also exhibit increased herbicide metabolism would provide valuable forensic evidence of the severity of herbicide resistance in California rice.Seedlings of smallflower populations from each of six ALS cross-resistance pattern were self-pollinated, and the resulting S-1 generation single seedlines were used for molecular genetic studies. Seedlings from S-1 generation resistant seedlines, as well as a known susceptible population, were harvested at the 3-leaf stage, and kept at -20°C. Frozen tissues were pulverized in a ball-mill, and DNA was extracted using a Takara® NucleoSpin Plant II® DNA kit. Amplification of ALS gene coding subunit, and PCR purification were conducted using Takara Primestar GXL® and Qiagen Qiaquick® kits, respectively. All molecular procedures were conducted in accordance with manufacturers' protocols. Sanger sequencing of purified PCR products was performed by GeneWiz®. ALS gene sequencing revealed single nucleotide polymorphisms (SNPs) corresponding to known sites of resistance-conferring mutations in five of the six smallflower populations under study. A double SNP at positions corresponding to Ala122 (GCC) resulted in a shift to Asn (AAC) in population R41, which was previously determined to be resistant to bensulfuron-methyl, bispyribac-sodium, and penoxsulam, but susceptible to halosulfuron-methyl. Population R41 previously showed evidence of increased glutathione S-transferase (GST) activity in the metabolism of penoxsulam, and paradoxically rapid P450 activity on halosulfuron-methyl. Substitutions at the site of Pro197 (CCT) were found in populations R3 and R4, resulting in Pro197-Ser (TCT) and Pro197-His (CAT), respectively. Population R3 was previously shown to be resistant to bensulfuron-methyl and halosulfuron-methyl. Population R4 was previously shown to be resistant to bensulfuron-methyl. Previous LC-MS work on R3 suggested increased P450 activity in bensulfuron-methyl metabolism, while R4 P450 activity was increased with halosulfuron-methyl only. Population R10 was revealed to have a substitution at Asp376 (GAT) resulting in Glu (GAG) at this site. This population is resistant to bensulfuron-methyl and bispyribac-sodium, and LC-MS studies suggested increased P450 and glucosyl transferase (GT) activity with bispyribac-sodium. Population R18 appears to have a substitution at Trp574 (TGG), resulting in Leu (TTG) at this site. This population is resistant to all applied ALS inhibitors, and did not show any evidence of increased herbicide metabolism from LC-MS studies. The combined results of the present and previous studies suggest that both target- and non-target mechanisms of ALS inhibitor resistance are present in some California populations of smallflower umbrella sedge. Knowledge of differential resistance can aid California rice growers and advisers in tailoring field-specific herbicide programs to minimize yield loss and slow the spread of resistance.

Voraxor^{TM}: A New Pre-seed Burndown Herbicide for Cereals and Pulse Crops in Canada.
Ethan Bertholet*; BASF Canada Inc., Saskatoon, SK, Canada (207)

Pre-seed or preemergence weed control is a critical step for weed management in the no-till/minimum till cropping system. Traditionally, a pre-seed burndown application of glyphosate provided adequate early season weed control. However, with increased incidence of herbicide resistance, particularly to glyphosate, it has become common practice to add an additional product as a tank mix partner with glyphosate to help control the spread of herbicide resistant weeds. VORAXOR^{TM} is a new pre-seed/preemergence herbicide for use in cereal and pulse crops in Western Canada. Voraxor^{TM} consists of two different protoporphyrinogen IX oxidase inhibitors (PPO), saflufenacil and a new PPO, trifludimoxazin. Efficacy trials conducted from 2015 to 2021 observed an increase in burndown and residual control of annual broadleaf weeds, such as kochia (*Kochia scoparia*) and volunteer canola (*Brassica napus*), with Voraxor when compared to either of the components applied alone. Due to its enhanced efficacy, integrating Voraxor^{TM} into a cereal or pulse herbicide program as a tank mix partner with glyphosate provides an effective pre-seed weed manage tool for Western Canadian growers.

TriVolt Herbicide: A New Residual Herbicide Combination for Weed Management in Corn. Eric Riley*; Bayer Crop Science, St. Louis, MO (210)

TriVolt™ is a new residual herbicide premix developed by Bayer CropScience for weed management in corn and is currently pending registration with the EPA. This product contains the following three active ingredients and the safener, cyprosulfamide: isoxaflutole, a Group 27 herbicide, thiencarbazone-methyl, a Group 2 herbicide, and flufenacet, a Group 15 herbicide. TriVolt will provide a resistance management option for corn growers with its combination of three different sites of action. In addition, this product will help provide broad spectrum and consistent weed control against common grass and broadleaf species in corn such as amaranths (*Amaranthus sp.*) and foxtails (*Setaria sp.*). Field studies were conducted in 2020 and 2021 to evaluate crop safety and residual weed control of TriVolt compared to Acuron® and Resicore® Herbicides. Atrazine was tank-mixed with TriVolt and Resicore and applications were made preemergence, at the time of planting. Overall, results from these studies indicate TriVolt can help provide excellent crop safety and consistent weed control. In both years, TriVolt provided similar levels of residual weed control compared to Acuron and improved residual grass control compared to Resicore, 56 days after treatment. With three different herbicide sites of action and a novel safener, TriVolt will be an effective, crop-safe and consistent weed management tool in corn.

Smoulder^{TM}: A New Pre-Seed Herbicide for Wheat and Barley. Brendan Metzger*[1], Ethan Bertholet[2], Brittany Hedges[3]; [1]BASF Canada Inc., Morden, MB, Canada, [2]BASF Canada Inc., Saskatoon, SK, Canada, [3]BASF Canada Inc., Lethbridge, AB, Canada (211)

Early season weed control is a critical component of an integrated weed management strategy, and effective burndown herbicides applied prior to seeding facilitate reduced or no-tillage production systems in cereals. Glyphosate is widely used in burndown applications; however increasing prevalence of glyphosate-resistant weed biotypes, herbicide tolerant crops and a lack of residual control on weeds such as volunteer canola, necessitates the use of tank-mix partners. Smoulder^{TM} is a new pre-seed herbicide for wheat and barley containing saflufenacil (Group 14) and metsulfuron-methyl (Group 2). Studies were conducted across Western Canada from 2016-2021 to evaluate crop tolerance and burndown/residual efficacy with Smoulder^{TM} compared to current standards. Smoulder^{TM} exhibited excellent broad-spectrum burndown control of annual weeds including herbicide-resistant biotypes of kochia, cleavers and volunteer canola, in addition to common perennial/winter annual species such as dandelion, narrow-leaved hawk's beard and Canada thistle. Additionally, Smoulder^{TM} provided extended residual control of secondary flushes of volunteer canola (all biotypes), filling a key need in canola-cereal rotations. Exceptional burndown activity utilizing the Group 14 mode of action, combined with excellent crop safety and rotational crop flexibility makes Smoulder^{TM} a robust pre-seed weed management solution for wheat and barley growers in Western Canada.

TVE29: A New Mode-of-Action Herbicide Interfering with *de Novo* Pyrimidine Biosynthesis for Effective Management of Herbicide-Resistant Grass Weeds Globally. Atul Puri*, Thomas Selby, Steven Gutteridge, Mark Holliday, Adam Prestegord; FMC Corporation, Wilmington, DE (213)

Title- Need to change to below: TVE29: A New Mode-of-Action Herbicide Interfering with *de Novo* Pyrimidine Biosynthesis for Effective Management of Herbicide-Resistant Grass Weeds Globally. Abstract: The agrochemical industry has struggled to discover a new herbicide mechanism in the last three decades. Here we report that TVE29 (tetflupyrolimet) is an exciting new herbicide with a novel mode of action for season-long control of major grass weeds in rice globally. TVE29 belongs to a new herbicidal class of aryl pyrrolidinone anilides that interferes with de novo pyrimidine biosynthesis via inhibition of dihydroorotate dehydrogenase enzyme enzyme that is localized to the mitochondria in the plants and is the first active ingredient in the HRAC/ WSSA Group 28. An extensive field program over the last 5+ years has shown that TVE29 provides season-long control of important grass weeds in the rice including *Echninochloa* sp and *Leptochloa* sp, as well as key broadleaf weeds such as *Monochoria* sp. and sedges such as *Fimbristylis* sp. TVE29 has excellent crop safety to both *japonica* and *indica* rice biotypes as well as transplanted or direct seeded rice under diverse soil and environments. Due to its novel mode of action, there is no evidence of TVE29 having cross-resistance with existing classes of herbicides. Discovered by FMC, TVE29 is a testament to FMC's commitment to innovation and a disciplined approach to advancing the most promising new molecules. The molecule is a significant innovation for the agriculture industry as it will help combat worldwide weed resistance. FMC anticipates launching TVE29 in both the transplanted and direct-seeded rice markets worldwide starting in 2024.

GROWing Into the Future: Outreach and Extension. Michael L. Flessner*[1], Mark VanGessel[2], Claudio G. Rubione[2], Eugene P. Law[3], Lauren M. Lazaro[4], Ramon G. Leon[5], Steven Brian Mirsky[6], John M. Wallace[7]; [1]Virginia Tech, Blacksburg, VA, [2]University of Delaware, Georgetown, DE, [3]University of Delaware, Beltsville, MD, [4]Louisiana State University, Baton Rouge, LA, [5]North Carolina State University, Raleigh, NC, [6]USDA- ARS, Beltsville, MD, [7]Penn State University, University Park, PA (214)

GROW (Getting Rid Of Weeds) is a publicly-led network coordinating research and outreach across twenty-one institutions. With respect to outreach, GROW provides universal, distilled, and applied weed management information through its website and social media platforms; in addition decision support tools are under development. These efforts are intended to expose farm decision makers to proven management techniques that may not be common in their region thereby facilitating diversification and adoption. Information and resources are intended to reach broad audiences, focusing on regional or national approaches. GROW does not seek to replace local knowledge and experience, rather compliment state-based resources. Since GROW's website launch in 2016, the website (growiwm.org/) has grown to over 50,000 page views and over 9,000 YouTube (GROW IWM) views in 2021, in addition to Twitter (@GROW_IWM), Instagram (@grow.iwm), and Facebook (facebook.com/GetRidofWeeds) interactions. GROW welcomes new participation in outreach and extension activities. GROW provides a platform that others can use, contribute to, and leverage. Each webpage is peer-reviewed from diverse geographies prior to publishing on the website. Assistance with video content creation, from planning, capturing, editing, and final publication can be provided. For motivated authors and content creators, the process can be very straightforward and time-efficient. All products credit both authors and reviewers and metrics are captured for annual reporting.

GROWing Into the Future: Research. Lauren M. Lazaro*[1], Michael L. Flessner[2], Eugene P. Law[3], Ramon G. Leon[4], Steven Brian Mirsky[5], Mark VanGessel[6], John M. Wallace[7]; [1]Louisiana State University, Baton Rouge, LA, [2]Virginia Tech, Blacksburg, VA, [3]University of Delaware, Beltsville, MD, [4]North Carolina State University, Raleigh, NC, [5]USDA- ARS, Beltsville, MD, [6]University of Delaware, Georgetown, DE, [7]Penn State University, University Park, PA (215)

Weeds are a major threat in agricultural production and are the cause of significant crop yield loss. Growers have multiple weed management options available to them, consisting of chemical and non-chemical tools. Reliance on any single method of weed control will not provide long-term weed management; such an approach often results in the development of herbicide resistant weeds. There is a need to examine various integrated weed management tactics across a large geographic scale that also incorporate current practices, such as crop rotation and cover crops. Getting Rid of Weeds (GROW; www.growiwm.org) is a publicly led network coordinating research and outreach, providing science-based information and decision support tools to make agriculture more sustainable and precise. GROW has three research initiatives that expands across 18 states and several cropping systems. The research initiatives include harvest weed seed control through seed impact mills and chaff lining, cover crops for weed suppression, and digital solutions for weed identification, mapping, and precision management. Each research area strives to provide information for farmers at the national, regional, and local levels so that site-specific weed management can be implemented.

Feral Rye (*Secale cereale*) Management with CoAXium and Clearfield Wheat Production Systems. Misha R. Manuchehri*[1], Hannah C. Lindell[1], Lane Scott Newlin[1], Caitlyn Carnahan[1], Justin T. Childers[2]; [1]Oklahoma State University, Stillwater, OK, [2]Oklahoma State University, Marlow, OK (216)

In southern Great Plains Winter Wheat, the Clearfield® System has historically been the only effective option to manage feral rye (*Secale cereale*) populations in-season. However, after the recent release of the CoAXium® System, there are now two herbicide tolerant technologies that can be utilized to control feral rye populations in wheat. To evaluate wheat response and feral rye control with Clearfield® and CoAXium® Systems, a study was established at Perkins, Oklahoma during the 2019-20 and 2020-21 winter growing seasons. Treatments included fall and/or spring imazamox or quizalofop-P-ethyl (quizalofop) applications made in Clearfield® or CoAXium® Systems, respectively. During the 2019-20 season, end-of-season visual control of feral rye was 93% or greater, regardless of herbicide tolerant system or treatment. However, during the 2020-21 season, control decreased by at least 20% for fall only treatments compared to those made in the spring or fall and spring. Fall followed by spring or spring only applications resulted in ~97% control of feral rye. Little to no visual crop injury was recorded following any herbicide treatment. Both Clearfield® and CoAXium® Systems are effective tools to manage feral rye in wheat; however, the number of feral rye flushes that occur in a growing season are variable and it is difficult to predict when a sequential herbicide treatment is needed. Finally, it is critical that these systems are stewarded to delay the selection for imazamox and quizalofop resistant biotypes of not only feral rye but other weed species. The best long-term strategy to control feral rye is crop rotation.

Crop Herbicide Tolerance Evaluation Using UAV Based Remote Sensing. Ryan D. Langemeier*, Livia Pereira, Justin T. McCaghren, Steve Li; Auburn University, Auburn, AL (219)

The use of unmanned arial vehicles in agriculture has increased rapidly in recent years. While use is often focused on field scale usage, opportunity also exists for data collection in research trials. One area of potential focus is crop tolerance which does not require the use of artificial intelligence to identify weeds. In the 2021 growing season two trials were conducted in Elmore and Escambia Counties, AL on both corn (*Zea maize*) and upland cotton (*Gossypium hirsutum*). Both crops received herbicide treatments both pre-emerge 0 weeks after planting (WAP), and post-emergence 4 WAP. Each crops had herbicides with 5 different modes of actions (MOA) applied; ALS, HPPD, PSII, PPO, and synthetic auxin. Each was MOA was applied both pre and post. Rates applied were either 300% or 25% of the maximum use rate depending on whether or not the products are rated for the crop respectively. The exception was 2,4-D post emerge to cotton which was 0.25% of the maximum use rate. Data collection involved visual injury and drone imagery collection 2, 4, 6, and 8 WAP. Heights were recorded at 4 and 8 WAP. Drone imagery was collected using a DJI Matrice 200v2 drone with a Sentera 6X camera at 18.3 meters. Imagery was then stitched using Pix4D mapper, and analysis was conducted using QGIS 3.16. Analysis for visual injury consisted of plot delineation, separation of green tissue area from soil background, and evaluation using the Enhanced Normalized Difference Vegetative Index (ENDVI). Following these steps, the green pixel count per plot, the sum value of ENDVI pixels following thresholding, and the mean value of the ENDVI pixels following thresholding was generated. These values were then compared to the visual injury ratings. Overall injury (sum value of ENDVI pixels following thresholding) correlations were low in Escambia Co. for corn (0.01 to 0.47); however injury levels were low was at that site. In Elmore Co. for corn correlations were high for overall injury (0.52 to 0.86), and all ratings before 56 DAT were 0.71 or higher. For cotton in Escambia Co. correlations were higher (0.79 to 0.9) as well as in Elmore Co. (0.88 to 0.94). Other metrics such as plant health and height correlations were highly variable. R^2 between stunting and green pixel count was very similar to overall injury and sum value of ENVDI pixels, and these two values had r^2 values between 0.98 and 1. These results suggest that the use of UAVs could potentially add an objective data measurement to crop tolerance evaluations while reducing labor and time demands relative to current practices.

Evaluation of Broadcast Partners with See &Amp; Spray™ in Soybean Production.
William L. Patzoldt*[1], Aaron Hager[2], Kip E. Jacobs[3], Michael M. Houston[4], Jason K. Norsworthy[4]; [1]Blue River Technology, Sunnyvale, CA, [2]University of Illinois, Urbana, IL, [3]University of Illinois, Champaign, IL, [4]University of Arkansas, Fayetteville, AR (220)

Evaluation of Broadcast Partners with See & Spray™ in Soybean Production William L. Patzoldt*[1], Kip E. Jacobs[2], Aaron G. Hager[2], Michael M. Houston[3], and Jason K. Norsworthy[3]; [1]Blue River Technology, Sunnyvale, CA, [2]University of Illinois, Urbana, IL, [3]University of Arkansas, Fayetteville, AR. Prototype See & Spray equipment was used to access the weed control efficacy, input cost savings, and yield protection associated with targeting weeds in soybean production. Targeting herbicide applications to weeds was made possible by combining real-time image capture with deep learning models able to differentiate weeds from soybeans (*Glycine max*). The research sprayer was also designed with a dual tank delivery system allowing specific herbicide product mixtures for See & Spray or broadcast applications. The dual tank system provided complete separation of product mixtures from the tank to individual nozzle tips on the boom, which allowed for the simultaneous application of mixtures not able to be combined in a single tank (e.g., dicamba and glufosinate for POST applications in soybean). Currently, tank mix combinations of dicamba and glyphosate are not permitted in the state of Arkansas, whereas combinations of dicamba and glufosinate are not allowed federally. Using this research sprayer, the objectives were to evaluate different herbicide broadcast partners with See & Spray applications of dicamba and determine if they could provide novel weed control options not encumbered by tank mix restrictions. Field trials were initiated in Greenville, MS, Urbana, IL, and Keiser, AR using soybeans with resistance to dicamba, glyphosate, and glufosinate. The standard broadcast program combined dicamba and clethodim in a single broadcast mixture and was compared with dicamba applied using See & Spray plus simultaneous broadcast applications of either clethodim, glyphosate, or glufosinate. Results suggest all See & Spray programs with dual tank options provided equivalent or improved weed control when compared with the standard broadcast program with no significant differences in soybean yield. In locations where weeds are resistant to glyphosate, herbicide programs with dicamba applied as See & Spray combined with broadcast applications of glufosinate in separate tanks could provide improved resistance management strategies utilizing herbicide programs with multiple effective sites-of-action. In summary, See & Spray machines with dual tank delivery systems would allow for more flexible and efficient weed control program options for soybean producers.

Kochia (*Bassia scoparia*) Patch Management with Physical Control Strategies. Shaun M. Sharpe*, Taylor Kaye; Agriculture and Agri-Food Canada, Saskatoon, SK, Canada (221)

Kochia is a problematic weed for conventional annual agronomic crops on the Canadian Prairies. Kochia is an early emerging, auto-allelopathic, patch forming tumbleweed. Herbicide-resistant kochia is a management challenge for Canadian Prairie agriculture due herbicide resistant biotypes occurring towards Groups 2, 4, and 9. Nonchemical management strategies are needed to supplement available options for producers to gain control of kochia. The study objective was to evaluate the efficacy of various physical control strategies. Treatments included applying hydro-mulch, black plastic mulch, and chaff as barriers. Mowing and planting of AC Saltlander was used as controls for patch management on field margins. Six field trials were conducted on producer land on established kochia infestations. The field season of 2021 was largely characterized by a drought in Saskatchewan. The planted AC Saltlander failed to emerge at all sites. The average kochia density in nontreated plots across all sites was greater than 1000 plants m^{-2}. The black plastic mulch was most effective as kochia was unable to penetrate through the mulch to emerge. The hydro-mulch was effective in suppressing kochia emergence but efficacy did wane later in the season. The chaff treatment was effective in suppressing kochia. The mowing treatment was also effective but later flushes of growth resulted in several mowing events necessary to maintain control. Results show promise for suppressing kochia using physical barriers. The cumulative impact for maintaining treatments for an additional two field seasons on kochia patch remediation will be evaluated.

Early Postemergence Guineagrass Control in Sugarcane. D Calvin Odero*[1], Alex G. Rodriguez[1], Venkatanaga Shiva Datta Kumar Sharma Chiruvelli[2]; [1]University of Florida, Belle Glade, FL, [2]University of Florida, Gainesville, FL (222)

Guineagrass (*Megathyrsus maximus*) is an important grass weed associated with Florida sugarcane. It is commonly found along field edges and ditch banks but has recently started encroaching inside sugarcane fields. Outdoor studies were conducted in Belle Glade, FL in 2021 to evaluate the efficacy of topramezone (25 and 50 g/ha) applied alone or in combination with atrazine (2,240 and 4,500 g/ha), metribuzin (1,120 and 2,240 g/ha), ametryn (450 and 900 g/ha), asulam (2,800 and 3,740 g/ha), and the premix of *S*-metolachlor + atrazine + mesotrione (3,100 g/ha). These were compared to asulam applied alone or in combination with trifloxysulfuron (16 g/ha), and the premix of *S*-metolachlor + atrazine + mesotrione applied alone. The herbicides were applied to guineagrass with two to three tillers and more than four tillers. Topramezone at both rates in combination with atrazine, metribuzin, and the premix of *S*-metolachlor + atrazine + mesotrione provided >90% control of the small size guineagrass and resulted in significant biomass reduction at 28 days after treatment (DAT). These treatments also resulted in >90% probability of no regrowth of guineagrass following harvesting of aboveground biomass. However, only the high rate of topramezone in combination with higher rates of atrazine, metribuzin, and the premix of *S*-metolachlor + atrazine + mesotrione provided >90% control of the big size guineagrass and resulted in significant biomass reduction at 28 DAT. These treatments also significantly reduced the probability of guineagrass regrowth after aboveground biomass reduction. These results showed that topramezone and tank-mix partners commonly used in Florida sugarcane can provide acceptable guineagrass control when applied at the early growth stage. The window to control much bigger plants is small and can only be achieved with the higher rate of topramezone in combination of the high rates of the aforementioned tank-mixes. Therefore, these herbicide programs can be used for management and to mitigate encroachment of guineagrass into sugarcane fields with proper timing of application in the Florida sugarcane cropping system.

Efficacy of Preplant Incorporated, Preemergence, and Postemergence Herbicides for Control of Waterhemp (*Amaranthus tuberculatus*) and Palmer Amaranth (*Amaranthus palmeri*) in Dry Bean. Joseph T. Ikley*, Nathan H. Haugrud, Stephanie DeSimini; North Dakota State University, Fargo, ND (224)

Herbicide-resistant waterhemp (*Amaranthus tuberculatus*) is becoming an increasingly problematic weed to control in dry bean in the Northarvest Bean Growers region, which encompasses North Dakota and Minnesota. Annual survey results indicate that waterhemp is one of the top three worst weeds in 20% of dry bean acres in the Northarvest Bean Growers region. Waterhemp populations resistant to ALS-inhibiting (Group 2) herbicides are of particular concern due to heavy grower reliance on using imazamox in their herbicide programs. Multiple herbicide-resistant Palmer amaranth has also been introduced into several counties in the region and could become a problem in dry bean production fields in the future. Two trials were conducted in 2021 to evaluate herbicide programs for control of ALS-inhibitor resistant waterhemp. All field experiments were conducted near Fargo, ND, conventionally tilled, and were conducted as RCBD with four replications. These experiments were also replicated on an ALS-inhibitor resistant Palmer amaranth population in Barnes county, ND. The first experiment was comprised of 16 treatments applied either PPI or PRE. Waterhemp and Palmer amaranth control ratings were evaluated every two weeks for eight weeks after planting. PPI-applied herbicides containing EPTC, ethalfluralin, trifluralin, pendimethalin, or sulfentrazone & *S*-metolachlor had the greatest control of waterhemp at the final rating, while PPI applications of EPTC, ethalfluralin, pendimethalin, EPTC + ethalfluralin, sulfentrazone & *S*-metolachlor, and sulfentrazone & carfentrazone + pendimethalin provided the greatest control of Palmer amaranth at the same rating interval. The second experiment evaluated 12 different POST herbicide programs for control of waterhemp and Palmer amaranth. EPTC + ethalfluralin were applied PPI, and POST treatments were applied to 5-cm waterhemp or Palmer amaranth, with 6 treatments receiving a planned sequential application of the same herbicides products and rates 7 days after initial treatment. Plots were evaluated for crop injury and weed control 7, 14, and 28 days after initial POST treatment. A single application of fomesafen (210 g ha^{-1}) or bentazon + fomesafen (1120 + 210 g ha^{-1}), or sequential applications of bentazon + fomesafen (560 + 105 g ha^{-1} fb 560 + 105 g ha^{-1}), or bentazon + fomesafen + imazamox (560 + 105 + 17.5 g ha^{-1} fb 560 + 105 + 17.5 g ha^{-1}) provided the greatest waterhemp control. All treatments containing fomesafen provided the greatest control of Palmer amaranth. These trials all provide insight into herbicide programs that can currently be used in conventionally-tilled dry bean to control herbicide-resistant waterhemp and Palmer amaranth. The trials will be repeated in 2022 to provide a second year of data on the utility of these herbicides to control these ALS-inhibitor resistant amaranth species.

Effect of Quinclorac on Wild Oat (*Avena fatua*) Fecundity and Seed Viability. Eric N. Johnson*, Christian Willenborg, Steve Shirtliffe; University of Saskatchewan, Saskatoon, SK, Canada (225)

Herbicide resistance in wild oat continues to spread in the Canadian Prairie Provinces. Surveys indicate that 30 to 40% of fields sampled contained multiple resistant (ACCase and ALS inhibiting herbicides) wild oat. Research on the effect of herbicides with alternative mechanisms of action on wild oat seed fecundity and viability is limited. Quinclorac is an auxinic herbicide that has both broadleaf and grass weed activity but does not provide control of wild oat. Quinclorac screening trials conducted on tame oat (*Avena sativa*) in the 1990's resulted in acceptable visual tolerance at vegetative stages; however, seed yield was reduced by as much as 80%. It was hypothesized that wild oat could experience similar reductions in seed production. A two-year study was conducted near Saskatoon, SK Canada. Quinclorac was applied at a rate of 125 g ai ha^{-1} to a monoculture stand of wild oat at five different growth stages (1-2 leaf, 4-leaf, 6-leaf, flag-leaf, and beginning of panicle emergence). Quinclorac application resulted in minimal vegetative phytotoxicity; however, it delayed panicle emergence and maturity. The herbicide treatment reduced seed shattering by as much as 68%. Wild oat seed yield (g m^{-2}) was reduced by as much as 57%, which corresponded to a similar reduction in thousand seed-weight. Seed fecundity was always reduced due to the reduction in seed size; furthermore, the viability of the seed was greatly reduced by quinclorac. Germination of wild oat seed treated with quinclorac was less than 5% compared to 69% for the non-treated check; additionally, >90% of the quinclorac treated seed was non-viable. Application timing of quinclorac at the 6-leaf stage resulted in the most consistent results. These preliminary results indicate a potential novel approach to herbicidal management of wild oat seed fecundity.

Effect of Soil Moisture Levels on Tolerance of Quizalofop-Resistant Cultivars to Quizalofop. Navdeep Godara*, Jason K. Norsworthy; University of Arkansas, Fayetteville, AR (229)

Quizalofop-resistant rice technology is a non-transgenic, herbicide-resistant technology that allows for postemergence applications of quizalofop, an acetyl CoA carboxylase-inhibiting herbicide. Previous research reported that quizalofop could cause significant injury to quizalofop-resistant cultivars, and soil moisture strongly influenced grass species' response to aryloxyphenoxypropionate herbicides. A greenhouse study was conducted to evaluate the effect of soil moisture content on quizalofop-resistant rice tolerance to quizalofop. Two experimental runs were conducted as a two-factor factorial, completely randomized design with three spatial replications. The factors evaluated were quizalofop-resistant cultivars as PVL01, PVL02, and RTv7231 MA and soil moisture content as 40%, 50%, 60%, 70%, 80%, 90%, and 100% of pore space filled with water. Air-dried soil weighed 8000 g was filled into 7.5 l buckets. Sequential applications of quizalofop were made at the recommended use rate; 120 g ai/ha at the 2-leaf stage, followed by a second application at the 5-leaf stage. All buckets were maintained at the desired moisture levels after germination until permanent flood establishment at five days after 5-leaf stage application. Higher injury and biomass reduction were observed on quizalofop-resistant cultivars maintained at saturated soils than low moisture content soils. Furthermore, a significant reduction in groundcover and height of PVL01 and RTv7231 MA cultivars was found compared to nontreated check on soils maintained at higher moisture levels when evaluated 28 days after treatment. Overall, results suggested that saturated soil conditions during quizalofop application timing exacerbated the injury to quizalofop-resistant rice and the severity of damage could be reduced by avoiding quizalofop applications during wet soil conditions.

Fall Application Timing for Sulfentrazone and Pyroxasulfone. Deanna McLennan*[1], Mitch Long[1], Kyle E. Schroeder[1], Pat Forsyth[2]; [1]FMC Canada, Saskatoon, SK, Canada, [2]FMC Canada, Wetaskiwin, AB, Canada (230)

Fall application of Authority® 480 (sulfentrazone 480 g/L), Authority® Supreme (pyroxasulfone 250 g/L, sulfentrazone 250 g/L) and Focus® (pyroxasulfone 447 g/L, carfentrazone 53 g/L) herbicides improves weed control consistency by using snowmelt for activation instead of early season rainfall. Authority® 480, Authority® Supreme and Focus® are soil-applied herbicides that require a minimum of 13 mm of moisture (rainfall or irrigation) for activation and to be most efficacious. In Western Canada, below average and inconsistent precipitation in the spring can lead to delayed activation of these herbicides resulting in reduced early season weed control. Research trials were conducted between 2019 and 2021 to evaluate the efficacy of a fall application timing on kochia (*Kochia scoparia trichophylla*), cleavers (*Galium spurium*), and wild oat (*Avena fatua*). When activating rainfall in spring was delayed fall application of Authority® 480 and Authority® Supreme herbicides increased early season kochia control by 30% compared to a spring application. Fall and spring application of Authority® 480 and Authority® Supreme had equal control of cleavers due to above average rainfall in the spring at the trial locations. Fall applied Focus® increased control of wild oat by 5% compared to the spring application. The application of Authority® 480, Authority® Supreme, and Focus® in the fall increases the likelihood of a moisture event that will successfully activate these herbicides and improves the consistency of efficacy on kochia, cleavers, and wild oat.

Application of Pre-emergent Oxyfluorfen as a Novel Chemical Control Option for California Weedy Rice (*Oryza sativa spontanea*). Liberty B. Galvin*, Kassim Al-Khatib; University of California, Davis, CA (231)

Weedy rice (*Oryza sativa spontanea*) is a concerning pest in California rice crops due to its competitive nature and conspecificity with cultivated rice (*Oryza sativa*). Chemical control options currently do not exist for this weed. ROXY rice, a trait-based technology, is oxyfluorfen-tolerant and poses an opportunity for chemically controlling weedy rice. Field trials occurring at the Rice Experiment Station in Biggs, CA, suggest that the ROXY program and associated pre-emergent oxyfluorfen provide exemplary weed control on rice field weeds. However, these trial fields do not contain weedy rice, so it was unknown as to whether or not oxyfluorfen would provide adequate control of weedy rice. The objective of this experiment was to determine if pre-emergent, pre-flood applications of oxyfluorfen could be a viable chemical control option for weedy rice. The experiment was repeated in time on UC Davis campus in a greenhouse facility. Weedy rice types 1, 2, 3, and 5 as well as M206, a medium grain, medium maturity cultivar, were planted at 1.3- and 2.5-cm soil depths. Oxyfluorfen was applied to the soil in pre-emergent application at rates of 0, 0.56, 1.12, 2.24, and 4.5 kg ai/hectare within a 187 L/hectare applicate volume. Once seeds were planted and pots were sprayed, blocks were flooded incrementally over 48-hours to a final 10 cm depth. Treatments were arranged within a randomized block design with a single herbicide rate for each block. Necrosis was the selected metric to represent visual injury ratings. Total emergence was recorded each day for the duration of the 28-day experiment. Weedy rice as well as M206 successfully emerged from all treatments, regardless of oxyfluorfen rate. There was significantly less emergence, 24%, from seeds exposed to 4.5 kg ai/hectare compared with 0.56 kg ai/hectare, 29%, but no significant difference in total emergence between seeds exposed to 0.56, 1.12, and 2.24 kg ai/hectare. All weedy types, as well as M206, exhibited significantly more necrosis compared with the untreated control groups and were completely necrotic by the end of 28 days, regardless of application rate. Results suggest that oxyfluorfen could be used as a pre-emergent chemical control option for weedy rice in California.

Oral 02. Horticultural Crops

The Potato Vine Crusher - A New Tool for Harvest Weed Seed Control. Andrew McKenzie-Gopsill*[1], Nicolle MacDonald[1], Laura Anderson[1], Scott N. White[2], Christine Noronha[1]; [1]Agriculture and Agri-Food Canada, Charlottetown, PE, Canada, [2]Dalhousie University, East Mountain, NS, Canada (232)

Harvest weed seed control (HWSC), an evolving paradigm in weed management, is highly effective for control of a variety of weed species in North American cropping systems. Previous devices for weed seed devitalization at harvest have been limited to tow-behind and integrated combine systems. The potato vine crusher (PVC) is a harvester-mounted set of rollers originally designed for crushing and control of *Ostrinia nubilalis* larvae during potato harvest. To evaluate potential of the PVC for HWSC, we conducted stationary testing of spring tension and roller speed settings to maximize control of *Chenopodium album*, the most problematic weed species in Canadian potato production. In addition, we evaluated efficacy of the PVC for control of several pernicious weed species under controlled conditions and during a simulated harvest. Increasing PVC spring tension reduced *C. album* control whereas roller speed had minimal effect. In contrast, maximized spring tension and minimized roller speed significantly reduced *C. album* germination (53%) in field soil. Hypocotyl and radical elongation was observed from *C. album* seed fragments under controlled conditions potentially contributing to increased control in field soil through fatal germination. High levels of control (65 – 94%) was observed for all tested species under controlled conditions. During simulated harvest, control of large weed seeds (50 – 63%) was observed whereas smaller seeds were not impacted signifying the importance of seed size for PVC efficacy. These studies demonstrate the PVC as a promising new tool for HWSC in Canadian potato production systems.

Allelopathy, Competitive Cultivars, and Cover Crops: IWM Tools for Sweetpotato Production. Isabel Schlegel Werle*, Matheus Machado Noguera, Srikanth Kumar Karaikal, Gustavo Bessa, Nilda Roma-Burgos; University of Arkansas, Fayetteville, AR (233)

Integrated weed management (IWM) systems that include non-chemical tactics for weed control are necessary as weed resistance to herbicides increases. Nine sweetpotato cultivars were evaluated for weed-suppressive ability, growth traits, and yield. Experiments were conducted at Fayetteville and Kibler, AR. The split-plot studies evaluated weed infestation (broadleaf spp., grass spp., or weed-free) as mainplot and nine sweetpotato cultivars as subplot. 'Beauregard-14' had the longest vines, whereas 'Hatteras' and 'Heartogold' had the tallest canopy at 5 and 7 WAT in Kibler and Fayetteville. 'Heartogold' had the largest leaf area at both locations. This cultivar reduced weed biomass 2- to 4-fold in both locations. Yield ranged from 27218 kg ha^{-1} to 77935 kg ha^{-1} in weed-free plots and was reduced by 53- and 63% with grass and broadleaf weeds across locations, respectively. 'Beauregard-14'and 'Bayoubelle-6'were the high-yielding cultivars in Kibler and Fayetteville. The best performing cultivars were integrated with cereal winter cover crops in Kibler and Augusta. The split-split plot tests included weeding (with or without) as mainplot; cover crop (winter wheat+clover, cereal rye+clover, fallow) as subplot; and sweetpotato cultivar (four) as sub-subplot. A 4.9-fold and 2.4-fold decrease in yield was observed in weedy plots in Augusta and Kibler, respectively. 'Bayou Belle-6' was the highest yielding cultivar at both locations. In Augusta and Kibler, rye+clover increased yield by 38 and 73%, respectively. Cultivars 'Bayou-Belle-6' and 'Beauregard-14' and mixed cover crops such as rye+clover are viable tools to reduce weed interference in IWM.

Impact of Anaerobic Soil Disinfestation and Soil Type on Weed Infestation,Guava Root Knot Nematode Viability and Sweetpotato Health. Matthew A. Cutulle*[1], Harrison T. Campbell[1], Phil Wadl[2], William Rutter[2]; [1]Clemson University, Charleston, SC, [2]USDA- ARS, Charleston, SC (234)

Weeds, and nematodes are limiting factors in sweetpotato production. These pests can be problematic to control as there is limited access to effective herbicides in sweetpotato and rising nematicide resistances. Improved Integrated Pest Management (IPM) strategies are needed to control these pests in sweetpotato. Anaerobic soil disinfestation (ASD) has the potential to fit into current pest management practices. ASD involves the application of a carbon source, irrigation to field capacity, and covering the soil with a plastic tarp. Changes in the soil microbial communities and production of volatile organic compounds during anaerobic decomposition are the main mechanism that kills biotic soil pests. Pests that would be a desirable target of ASD would include yellow nutsedge, Palmer amaranth, guava root knot nematode and southern root knot nematode . A greenhouse study was conducted at the Clemson Coastal Research and Education center in Charleston, SC to specifically look at the impact of cotton seed meal in a greenhouse container study to look at the impact of carbon source and soil type on cumulative anaerobicity, weed control and sweetpotato vigor. Five-gallon home depot buckets were filled with three different soil types (Charleston-loamy, Blackville-coarse high sand content, and Clemson-high clay content) and were mixed with cotton seed meal (CSM) or no carbon amendment. Each bucket was inoculated with Guava root not nematode. ORP, pH and temperature probes were placed in each pot and connected to a data logger. Tiff film was then sealed over the plots. The pots remained sealed for 5 weeks. After five weeks the plastic was removed and sweetpotato slips (Bayou Belle) were transplanted. Cumulative anaerobicity, weed counts, sweetpotato vigor, weed biomass and nematode counts were taken throughout the study. The results of this study indicated higher organic soils are more conducive to longer periods of anaerobicity. Plots that went anaerobic generally had less weeds and nematodes when compare to plots that did not go anaerobic.

Plasticulture Vegetable Production is Influenced by Residual Activity of Glyphosate and Glufosinate Applied Preplant. Taylor M. Randell*, Lavesta C. Hand, Hannah E. Wright, A Stanley Culpepper; University of Georgia, Tifton, GA (236)

In fields utilized for plasticulture vegetable production in Georgia, a single installation of plastic mulch may be utilized for up to five cropping cycles over an 18-month period. Preplant burndown herbicides are critical to control emerged weeds prior to planting vegetable crops in this system; glyphosate and glufosinate are effective options for troublesome weeds and may be removed from the mulch surface with overhead irrigation, preventing crop injury from foliar splashing. It is unknown, however, if herbicide concentration in the exposed soil of old plant holes, rips, tears or other areas of plastic degradation will injure newly planted vegetable transplants through residual activity. Six field studies were conducted from 2019 to 2021 to determine tomato, cucumber, and squash response to residual glyphosate and glufosinate when applied prior to transplanting into 1) a new plant hole, avoiding contact with treated soil (new hole), 2) an old plant hole, contacting treated soil (old hole), or 3) a new plant hole punched 15 cm from an old plant hole (adjacent hole). Within each planting arrangement study, four rates of each glyphosate (0, 1.54, 3.08, and 6.17 kg ai ha^{-1}) and glufosinate (0, 0.66, 1.31, and 2.62 kg ai ha^{-1}) were arranged in a randomized complete block design and included four replications per study. Following treatment application, but prior to transplanting, overhead irrigation was utilized to remove the herbicide from the mulch surface. For all crops, visual injury, crop growth, fresh-weight biomass, and yield were evaluated; tomato, cucumber, and squash were harvested 13-16, 15, and 21-30 times, respectively. *Glyphosate*. When the crop was placed into a new or adjacent plant hole, crop injury was less than 4%, with no significant impacts on crop growth or yield. When planted into an old plant hole, however, tomato, cucumber, and squash were injured 23-40%, biomass was reduced 41-65%, and yield (fruit weight) was reduced 10-36% from glyphosate applied at 6.17 kg ai ha^{-1}. Applications of glyphosate at 1.54 and 3.08 kg ai ha^{-1} injured crops 4-12%, but did not reduce crop yield. *Glufosinate*. When the crop was placed into a new or adjacent plant hole, crop injury was less than 8%, with no significant impacts on crop growth or yield. Regardless of rate, tomato was not injured when placed into an old plant hole. For cucumber and squash, however, resulting injury was 35-76%, biomass was reduced 44-88%, and fruit weight losses ranged from 57-70% from glufosinate at 1.31 and 2.62 kg ai ha^{-1}. Glufosinate at 0.66 kg ai ha^{-1} injured cucumber and squash 8-10%, but did not impact crop growth and yield compared to the control. Results indicate that tomato, cucumber, and squash transplanting can safely follow preplant glyphosate or glufosinate over plastic mulch, only if the mulch is washed prior to planting, and the plants are placed into a new or adjacent plant hole. If transplants contact soil treated with the studied herbicides, significant crop injury and yield reductions may result.

A Multi-State Evaluation of Pumpkin Tolerance to Delayed PRE Applications of *S*-Metolachlor.
Thierry E. Besancon[1], Sushila Chaudhari[2], Douglas Doohan[3], Harlene M. Hatterman-Valenti*[4], Katherine M. Jennings[5], Dwight Lingenfelter[6], Stephen L. Meyers[7], Lynn M. Sosnoskie[8], Mark VanGessel[9], Kurt M. Vollmer[10]; [1]Rutgers University, Chatsworth, NJ, [2]Michigan State University, East Lansing, MI, [3]The Ohio State University, Wooser, OH, [4]North Dakota State University, Fargo, ND, [5]North Carolina State University, Raleigh, NC, [6]Penn State University, University Park, PA, [7]Purdue University, West Lafayette, IN, [8]Cornell University, Geneva, NY, [9]University of Delaware, Georgetown, DE, [10]University of Maryland, Queenstown, MD (237)

Field trials were conducted in ten states [Delaware, Indiana (two locations), Maryland, Michigan, New Jersey, New York, North Carolina, North Dakota, Ohio, and Pennsylvania] in 2021 to determine the impact of delayed PRE applications of *S*-metolachlor on pumpkin crop tolerance and yield. The experiment design was a randomized complete block with 3 to 4 replications per location. The full treatment set consisted of three *S*-metolachlor rates (0, 1.4 and 2.8 kg ai ha^{-1}) by two halosulfuron-methyl rates (0 and 26 g ai ha^{-1}) by two application timings (approximately 2 and 4 weeks after planting), however, treatments varied by location. Visual crop injury on a scale of 0 (no injury) to 100% (crop death) was recorded throughout the season and injury ratings were averaged across 3 and 4 weeks after planting, 5 and 6 weeks after planting, and 7 and 8 weeks after planting. Total fruit number was collected at all locations. With the exception of Pennsylvania, aggregate or individual fruit weight data were collected. Pumpkins in Delaware were graded by diameter into small (18 to 23 cm), medium (23 to 28 cm), large (28 to 33 cm), and extra large (> 33 cm). Similarly pumpkins in Pennsylvania were graded by diameter into small (18 to 23 cm), medium (23 to 30 cm), and large (30 to 38 cm). No injury was observed at the Ohio location throughout the course of the study. At 3 to 4 weeks after planting, pooled across halosulfuron rates, there were no difference in crop injury between S-metolachlor rates at Indiana, New Jersey, and New York. Maryland (15% vs 0%) and North Carolina (23% vs 13%) reported slightly greater injury from 1.4 kg ha^{-1} *S*-metolachlor than 2.8 kg ha^{-1} *S*-metolachlor. At Pennsylvania *S*-metolachlor at 2.8 kg ha^{-1} resulted in greater crop injury than 1.4 kg ha-1 (20% vs 7%). At Delaware and Michigan, there was a significant halosulfuron rate-by-*S*-metolachlor rate interaction. At both states, when applied alone *S*-metolachlor injury was greater with 2.8 kg ha^{-1} (18% and 17%, respectively) than 1.4 kg ha^{-1} (8% and 1%, respectively). When applied with 26 g ha^{-1} halosulfuron, injury at Delaware and Michigan did not differ by *S*-metolachlor rate. Injury was generally greater when halosulfuron was applied alone or in combination with *S*-metolachlor compared to application of *S*-metolachlor alone.No harvest data were collected at Ohio due to a late season crop failure. Pooled across locations, total pumpkin number, average fruit weight, and yield of the non-treated control was 2,425 fruit ha^{-1}, 5.5 kg per fruit, and 545,365 kg ha^{-1}, respectively. Pooled across application timings, treatments consisting of *S*-metolachlor at 1.4 or 2.8 kg ha^{-1} resulted in fruit number and total yield similar to the non-treated control. However, when halosulfuron was applied alone, pumpkin fruit number (2,133 fruit ha^{-1}) and yield (419,095 kg ha^{-1}) were reduced. Pooled across all *S*-metolachlor and halosulfuron rates, applications made 2 weeks after planting resulted in greater fruit number (2,971 pumpkin fruit ha^{-1}) than the non-treated control and similar fruit number to applications made 4 weeks after planting (2,544 pumpkin fruit ha^{-1}). Pooled across application timings, pumpkins treated with halosulfuron alone had reduced mean fruit weight (4.3 kg) compared to plots treated with either rate of S-metolachlor (5.4 to 5.5 kg). Total yield was greater when pumpkins were treated 2 weeks after planting (560,998 kg ha^{-1}) compared to 4 weeks after planting (527,856 kg ha^{-1}). At Delaware, large pumpkin fruit yield was 3,474 fruit ha^{-1} in the non-treated control, and large fruit were reduced by 1.4 kg ha^{-1} *S*-metolachlor (2,115 fruit ha-1), 26 g ha^{-1} halosulfuron (2,455 fruit ha-1), and applications made 2 weeks after planting (1,964 fruit ha^{-1}). Large fruit at Pennsylvania were also reduced with herbicide application made 2 weeks after planting (319 fruit ha^{-1}) compared to 4 weeks after planting and the non-treated control (1,531 and 1,148 fruit ha^{-1}, respectively).

Spring Seeded Grass Cover Crops for Weed Suppression in Cucurbit Crops. Kurt M. Vollmer*[1], Thierry E. Besancon[2], Baylee L. Carr[2]; [1]University of Maryland, Queenstown, MD, [2]Rutgers University, Chatsworth, NJ (238)

Weed control between plastic rows can be difficult due to a lack of effective herbicides, a need for multiple cultivations, or hand labor. Previous research has shown seeding cereal rye in between plastic rows in the spring provides weed suppression early in the growing season, but does not provide full-season weed control. Therefore, the objectives of this study were to evaluate different cover crop management tactics on weed suppression, evaluate cover crops for reducing herbicide applications, and demonstrate the utility of cover crops for weed management in plasticulture production. A common study was conducted in 2021 to assess the effects of integrating spring-seeded grass cover crops with herbicide treatments for weed control in cucumber and watermelon. The study consisted of a three-factor factorial arranged in a split-split plot design with four replications. The whole plot consisted of cover crop termination method (clethodim, paraquat, and no-herbicide/rolled). Subplots consisted of cover crop species (cereal rye, spring oat, cereal rye + spring oat, and no cover crop), and sub-subplots consisted of residual herbicide treatment (fomesafen + *S*-metolachlor and no residual herbicide). In both studies, cover crops improved overall weed control compared to no cover crop treatments. Cover crops reduced at-planting weed density 55% in the cucumber trial and 64% in the watermelon trial. In the cucumber study, spring oat treatments controlled weeds 73% to 79% 6 weeks after planting, regardless of termination method. Cereal rye and cereal rye + spring oat treatments provided similar control when terminated with clethodim or paraquat. In the watermelon study, spring oat and cereal rye + spring oat treatments controlled weeds 89% to 93% 6 weeks after transplant, regardless of termination method. Cereal rye treatments provided similar control when terminated with paraquat or with no-herbicide/rolled. Cucumber yields were higher with cover crop treatments compared to no cover crop treatments, regardless of cover crop species. Watermelon yields were higher with cover crop treatments compared to no cover crop treatments, but cereal rye and spring oat + cereal rye treatments had higher yields than spring oat treatments. These results confirm that spring-seeded grass cover crops can be integrated into programs for weed control in plasticulture crops.

Evaluation of Amino Acid-inhibiting Herbicide Tank Mixtures for Hair Fescue (*Festuca filiformis*) Management in Wild Blueberry (*Vaccinium angustifolium* Ait). Scott N. White*; Dalhousie University, East Mountain, NS, Canada (240)

Hair fescue is a tuft-forming perennial grass that reduces lowbush blueberry yield. The currently registered amino acid-inhibiting herbicides foramsulfuron and nicosulfuron+rimsulfuron (ALS/AHAS-inhibitors), glufosinate (glutamine synthesis-inhibitor), and glyphosate (EPSP synthase-inhibitor) exhibit variable efficacy on hair fescue when applied alone. Tank mixtures of herbicides with complimentary modes of action, however, can improve weed control but have not been evaluated for hair fescue management in wild blueberry. This research utilized a 4 X 3 factorial arrangement of group 2 herbicide (none, foramsulfuron, nicosulfuron + rimsulfuron, flazasulfuron) and tank mixture (none, glyphosate, and glufosinate) to identify possible tank mixtures that improve weed control and manage resistance development. Herbicides were applied in spring non-bearing year, fall bearing year, and fall non-bearing year, with each application timing conducted as a separate experiment. Foramsulfuron and nicosulfuron + rimsulfuron were not effective as fall applications and spring applications of these herbicides in tank mixture with glyphosate or glufosinate improved hair fescue suppression. Glyphosate and glufosinate were more effective when applied in fall relative to spring. Flazasulfuron was effective across all application timings, though tank mixture with glufosinate generally gave greater hair fescue suppression than flazasulfuron and flazasulfuron + glyphosate. Flazasulfuron + glufosinate is tentatively recommended as an effective tank mixture for spring non-bearing and fall bearing year hair fescue management in wild blueberry.

Smart Spray Technology for Weed Management in Tomato. Nathan Boyd*[1], Arnold Schumann[2]; [1]University of Florida, Balm, FL, [2]University of Florida, Lake Alfred, FL (241)

Purple nutsedge is a troublesome weed in plasticulture vegetable production systems due in part to its prolific reproduction and ability to puncture the plastic mulch. Halosulfuron can be applied POST in some crops such as tomato for nutsedge control. Herbicide applications only where weeds occur would reduce herbicide usage and risk of crop damage. Two convolutional neural networks were trained to dectect nutsedge on plastic covered beds. The models were incorporated with a prototype precision herbicide sprayers. The efficacy was evaluated in field trials when using single-shot Multibox detection (SSD) network versus a YoloV3-Tiny-3L network. In the first experiment, the SSD convolutional neural network detected 99% (Precision=0.99) of nutsedge and had >90% overall accuracy (F-score = 0.94 and 0.90). In the second experiment, the Yolo-TinyV3-3L network had significantly higher accuracy when tractor speed was 1.6 and 3.2 km/h compared to 6.4 km/h. The number of false-positive increased as the tractor speed increased. Overall, precision herbicide applications reduced spray volume upto 82% compared to banded applications.

Oral 03. Turf and Ornamentals

Celsius XTRA: A New Bayer Turfgrass Herbicide. Devon E. Carroll*[1], Bruce Spesard[2], James W. Hempfling[2], Sheryl Wells[3], Jeffery Michel[2], Patrick Burgess[2]; [1]University of Tennessee, Knoxville, TN, [2]Bayer Crop Science, Cary, NC, [3]Bayer Crop Science, Milledgeville, GA (242)

Employee attrition is something all lawn care operators (LCOs) are facing in today's economic landscape. Eliminating the need to educate employees about tank mixing products to address broadleaf weed and sedge concerns allows more lawns to be treated and done so without error. As a solution to remove risk from the mix, Bayer Environmental Science recently introduced Celsius® XTRA (CX) – an all-in-one broadleaf weed and sedge control herbicide. CX is a novel, pre-mixed herbicide containing three acetolactate synthase (ALS) inhibiting (WSSA Group 2 [HRAC legacy Group B]) active ingredients: thiencarbazone-methyl + iodosulfuron-methyl-sodium, which are proprietary Bayer chemistries, + halosulfuron-methyl. CX received registration with the Environmental Protection Agency in March of 2021 and was released to customers in August of 2021. The product is currently registered in 37 states for use by commercial applicators on warm-season turfgrasses including bermudagrass (*Cynodon* spp.), St. Augustinegrass [S*tenotaphrum secundatum* (Walter) Kuntze), zoysiagrass (*Zoysia* spp.), and centipedegras [*Eremochloa ophiuroides* (Munro) Hack.]. Applications of CX may be made to institutional, commercial, industrial, sports, and residential turfgrass sites in addition to sod farms. CX is labeled for post-emergence (POST) control of 106 broadleaf, sedge, and kyllinga species including troublesome weeds such as ground ivy (*Glechoma hederacea* L.), dandelion (*Taraxacum officinale* Weber x Wiggers), white clover (*Trifolium repens* L.), yellow nutsedge (*Cyperus esculentus* L.), and green kyllinga (*Kyllinga brevifolia* Rottb.). The "Caution" signal word labeling of CX offers customers operational flexibility enhanced by the herbicide's minimal odor and low PPE requirements. Additionally, the non-phenoxy chemistry of CX provides broadleaf weed control with limited herbicide drift concerns. CX is formulated as a water-dispersible granule (WDG) with a recommended rate structure of 525 g CX ha^{-1} (7.5 oz $acre^{-1}$) with a sequential application at 525 g CX ha^{-1} (7.5 oz $acre^{-1}$) at a 6- to 8-week interval, which is a typical customer visit interval for LCOs. The annual maximum application rate is 159.5 g ai ha^{-1} (15 oz CX $acre^{-1}$), aligned with the low-use rates typical of ALS inhibiting herbicides. As a new, all-in-one POST herbicide mixture, CX meets customer needs by providing wide-spectrum weed control in warm-season turfgrass systems with less risk of turf injury stemming from tank mixing errors.

Multi-State Survey of Target Site Resistance Alleles for Four Modes of Action in Annual Bluegrass (*Poa annua*). Claudia A. Rutland*[1], Eli C. Russell[2], Nathan D. Hall[3], Jinesh Patel[1], Shawn Askew[2], Muthukumar V. Bagavathiannan[4], Rebecca Bowling[4], James Brosnan[5], Travis Gannon[6], Clebson G. Goncalves[2], Daniel Hathcoat[4], Lambert B. McCarty[7], Patrick McCullough[8], James D. McCurdy[9], Aaron Patton[10], J Bryan Unruh[11], Joseph S. McElroy[1]; [1]Auburn University, Auburn, AL, [2]Virginia Tech, Blacksburg, VA, [3]Michigan State University, East Lansing, MI, [4]Texas A&M University, College Station, TX, [5]Univeristy of Tennessee, Knoxville, TN, [6]North Carolina State University, Raleigh, NC, [7]Clemson University, Clemson, SC, [8]University of Georgia, Griffin, GA, [9]Mississippi State University, Starkville, MS, [10]Purdue University, West Lafayette, IN, [11]University of Florida, Gainesville, FL (244)

Poa annua L., or annual bluegrass, is a common weed in turfgrass. P. annua has been found resistant to nine different herbicide modes of action and some cases of multiple resistances within the same population. In an effort to quantify the spread of herbicide resistant P. annua across the country, the ResistPoa Project (http://resistpoa.org) surveyed 1367 P. annua populations for resistance to nine modes of action and a single fungicide. Herein we report results from sequencing of known target site mutations found in EPSPS, ALS, psbA, and ??-tubulin genes. Populations were sequenced using either capillary or amplicon sequencing (AmpSeq), depending on the complexity of the gene, and analyzed for target site resistance. 463 suspected resistant populations were sequenced, of which 131 for ALS, 84 for EPSPS, 93 for psbA, and 78 for ??-tubulin. 77 of these populations also displayed resistance to multiple modes of action. Of these populations, 65.6% of ALS, 73.8% of EPSPS, 38.7%% of psbA, 97.4% of ??-tubulin, and 44.2% of populations with multiple resistances presented with a target site mutation at the Trp574, Pro106, Ser264, and Thr239 sites respectively.

A Bioassay to Determine *Poa annua* Responses to Indaziflam. Benjamin D. Pritchard*[1], Jose J. Vargas[1], Bruce Spesard[2], James Brosnan[3]; [1]University of Tennessee, Knoxville, TN, [2]Bayer Crop Science, Cary, NC, [3]Univeristy of Tennessee, Knoxville, TN (245)

Herbicide resistance within *Poa annua* is widespread in managed turfgrass systems. In 2020, a *P. annua* collection from a golf course in the southeastern United States was reported to be resistant to indaziflam as well as six other mode-of-action groups. Considering *P. annua* is the most troublesome weed in turfgrass, a bioassay to screen other collections with putative indaziflam resistance is needed. A dose response experiment was conducted with ten concentrations of indaziflam (0, 250, 500, 750, 1000, 1250, 1500, 2000, 4500, and 9000 pM) in Gelrite® culture during 2021. An herbicide-susceptible (S1) collection of *P. annua*, a resistant standard (Site 3A), and a collection with putative-resistance to indaziflam (Site 18) were included in this experiment. Petri dishes were filled with 80 mL of Gelrite® (3.75 g L^{-1}) containing technical grade (= 98%) indaziflam (Sigma-Aldrich, St. Louis, MO) and rifampicin (1000 ppm). Each plate was sealed with parafilm after placing 15 seeds of a single collection on the Gelrite® surface. During the experiment, all plates were placed at a 75° angle to facilitate gravitropic root growth and stored in a growth chamber set to a constant air temperature of 16 °C. Each indaziflam concentration was replicated five times per *P. annua* collection. At 14 days after seeding (DAS), the length of root tissue (mm) protruding from each seed was recorded with digital calipers. Root length data from each *P. annua* collection (N = 75) were expressed as a percentage of the non-treated (0 pM indaziflam) and subjected to non-linear regression analysis to calculate indaziflam concentrations required to reduce root growth by 75% (EC_{75}). Statistically significant differences were detected among *P. annua* collections with the EC_{75} for the herbicide-susceptible collection measuring 740 pM [95% confidence interval (CI) = 663 to 829 pM] compared to 2685 pM (CI = 2137 to 3559 pM) for Site 3A and 4819 pM (CI = 3413 to 7459) for Site 18. This work will be repeated in 2022 to further validate a discriminatory dose to screen *P. annua* responses to indaziflam in Gelrite® culture.

A Common Garden Study to Evaluate Morphological Trait Diversity in Annual Bluegrass (Poa Annua L.). Andrew W. Osburn*[1], Rebecca Bowling[2], Muthukumar V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]Texas A&M University, Dallas, TX (246)

Annual bluegrass (*Poa annua* L.) is an extremely problematic polycarpic weed in various turfgrass systems across the United States, drastically driving up management costs and greatly reducing the aesthetic value of turfgrass landscapes. Since annual bluegrass can express resistance to as many as nine unique herbicide sites-of-action, including cross resistances, and has been known to exhibit various growth habits and life cycles based on its growing environment, many turfgrass managers are left with very few tools in their toolbox to control this weed. Additionally, annual bluegrass has been found infesting all major landmasses including Antarctica. This weed has demonstrated high adaptive potential, but not much is known about how readily and successfully different populations of annual bluegrass will adapt to new turfgrass environments. In fall of 2020, ten unique populations of annual bluegrass from various plant hardiness zones were planted into a common environment in College Station, Texas and various morphological and adaptive traits were measured. We observed a high degree of variability across populations from different geographic locations. General trends were that the southern annual bluegrass populations had greater number of individuals with early-flowering phenotype, whereas annual bluegrass from more northern areas expressed greater early-season tiller production, spring regrowth biomass, and total plant biomass at maturity. All annual bluegrass populations evaluated here established and reproduced successfully, though phenotypic heterogeneity exhibited across the unique populations suggests that annual bluegrass retained the adaptive traits of their maternal parentage. Findings indicate that annual bluegrass infestations into new areas are likely seed limited, rather than limited by their ability to adapt. Efforts should be placed in preventing seed dispersal at all levels, from local to regional and even further.

Influence of Turfgrass Species, Fertility Program, and Plant Growth Regulators on Floral Density of a Bulb Lawn. Daewon Koo*[1], Shawn Askew[1], Mike Goatley[1], John R. Brewer[2], Clebson G. Goncalves[1], John M. Peppers[1]; [1]Virginia Tech, Blacksburg, VA, [2]Syngenta Crop Protection, Vero Beach, FL (248)

"Bulb lawns" or "bulb meadows" include a polyculture of managed turfgrass and spring-flowering, bulb plants. Bulb plants used for this purpose typically evolved in alpine locations that have compressed growing seasons. Thus, these plants are well suited to emerge from dormancy, provide a spring floral display, and reenter dormancy in the span of a few months in early spring. The short growing season of bulb plants begins before turfgrass initiates spring growth and ends soon after turfgrass reaches optimal growth in early summer. Increased nitrogen in turfgrass systems would be expected to increase the competitiveness of turfgrass with bulb plants and decrease bulb persistence via microbial degradation. Plant growth regulators could be used to reduce turfgrass competitiveness in late spring while bulb plants are storing carbohydrates for the upcoming dormancy season. Few research studies have investigated factors, such as fertility programs or turfgrass species, that influence incorporation of flower bulbs into managed turfgrass systems. The objective of this study is to evaluate the influence of turf species, fertility programs, and bulb-plant species on floral density under management as a bulb lawn. Field trials were conducted at Virginia Tech's Glade Road Research Facility and Turfgrass Research Center in Blacksburg, VA for 2 and 3 years, respectively. Studies were established as randomized complete block designs with a split-plot treatment arrangement. Main plots included a 2 x 5 factorial arrangement of turf species by fertility programs. Subplots included rows of 10 bulbs for each of 7 flower bulb species including *Iris histroides* 'Katherine Hodgkin', *Crocus chrysanthus* 'Cream Beauty', *Crocus tommasinianus* 'Ruby Giant', *Muscari azureum* 'Grape Hyacinth', *Muscari azureum* 'Venus', *Narcissus ssp.* 'Rip Van Winkle', and *Narcissus jonquilla* 'Baby Moon'. The five fertility programs included no fertility, turfgrass-based nitrogen fertilizer (N), bulb-plant-based phosphorous and potassium fertilizer (PK), integrated fertility that includes nitrogen, phosphorous, and potassium fertilizer (NPK), and NPK plus fluazifop at 105 g ai/ha as a turfgrass growth regulator (NPK+TGR). The two turfgrass species were established over bulbs by laying sod, and these included *Lolium arundinaceum* and *Festuca rubra*. The two most abundant flowering bulb species were *C. tommasinianus* 'Ruby Giant' and *N. jonquilla* 'Baby Moon' with an average of 32 and 35 blooms per plot, respectively in the first season. The seasonal bloom count of *C. tommasinianus* 'Ruby Giant' increased 30% by the third growing season while that of *Narcissus jonquilla* 'Baby Moon' decreased 85% in the same period. *F. rubra* decreased bloom density of most species when compared to *L. arundinaceum*. Only three bulb species responded to the fertility program with respect to bloom density and this response was dependent on turfgrass species. These included *I. histroides* 'Katherine Hodgkin', *C. chrysanthus* 'Cream Beauty', and *N.* 'Baby Moon'. In general, bloom density increased in programs that included PK and was the highest in programs that included NPK. Fertility effects were no longer evident at three years after planting. Long-term bloom density appeared to be governed more by bulb species and turfgrass type than by other factors.

Oral 04. Pasture, Range, Forest, & Rights of ways, Wildland, and Aquatic Invasive plants

2021 Survey Results for the Most Common and Troublesome Weeds in Aquatic and Non-Crop Areas. Lee Van Wychen*; Weed Science Society of America, Alexandria, VA (250)

The 2021 Weed Survey for the U.S. and Canada surveyed the most common and troublesome weeds in: 1) irrigation and flood control; 2) lakes, reservoirs, and rivers; 3) ponds; 4) forestry; 5) parks and refuges; 6) ornamentals: field nursery crops, outdoor containers, and Christmas trees; and 7) right-of-ways: railways, roads, public utilities. Common weeds refer those most frequently seen while troublesome weeds are the most difficult to control, but not necessarily widespread. There were 289 total survey responses from the U.S. and Canada. Canadian responses were limited to the provinces Alberta, Quebec, Ontario, and Prince Edward Island. No responses were submitted from Alaska, Georgia, Hawaii, Illinois, Louisiana, Maine, New Jersey, New Mexico, North Dakota, South Dakota, and West Virginia. Across all surveyed aquatic areas (irrigation, lakes, and ponds) the three most common and troublesome weeds were 1) *Myriophyllum spicatum*; 2) *Hydrilla verticillata*; and 3) *Eichhornia crassipes*. The top three common weeds in irrigation were 1) *Eichhornia crassipes*; 2) *Pistia stratiotes*; and 3) a tie between *Rotala rotundifolia* and *Stuckenia pectinate* while the most troublesome weeds were 1) *Nymphoides cristata*; 2) *Eichhornia crassipes*; and 3) *Vallisneria americana*. The top three most common and troublesome weeds in lakes were *Myriophyllum spicatum*, *Hydrilla verticillata*, and *Potamogeton crispus*. The top three most common weeds in ponds were 1) *Algae* spp.; 2) *Typha* spp.; and 3) *Hydrilla verticillata* whereas the three most troublesome weeds were 1) *Algae* spp.; 2) *Nymphoides* spp.; and 3) *Eleocharis baldwinii.* Across all surveyed terrestrial areas (forests, parks, ornamentals, and right of ways), the three most common weeds were 1) *Cirsium arvense*; 2) *Alliaria petiolata*; and 3) *Cardus nutans* while the most troublesome weeds were 1) *Cirsium arvense*; 2) *Microstegium vimineum*; and 3) *Ailanthus altissima.* The top three most common weeds in forests were 1) *Cirsium arvense*; 2) *Alliaria petiolata*; and 3) *Carduus nutans* while the most troublesome weeds were 1) *Microstegium vimineum*; 2) *Cirsium arvense*; and 3) a tie between *Cynoglossum officinale* and *Celastrus orbiculatus.* The most common weed in parks was a three-way tie between *Schinus terebinthifolius*, *Imperata cylindrica*, and *Allaria petiolata* while the most troublesome weeds were 1) *Imperata cylindrica*; and 2) a three-way tie between *Microstegium vimineum*, *Lygodium microphyllum, Ailanthus altissima*. The most common weeds in ornamentals was 1) *Euphorbia maculata*.; 2) *Conyza canadensis;* and 3) a three-way tie between *Taraxacum officinale*, *Cyperus* spp., and *Artemisia vulgaris* while the most troublesome weeds were 1) *Cyperus* spp.; 2) *Digitaria* spp.; and 3) *Oxalis* spp. The most common weeds for right-of-ways were 1) a tie between *Cirsium arvense* and *Bassia scoparia* followed by 3) *Pastinaca sativa* while the most troublesome weeds were 1) *Bassia scoparia*; 2) *Phragmites australis*; and 3) a three way tie between *Salsola tragus, Reynoutria japonica,* and *Pastinaca sativa*. The 2021 weed survey data is available at: www.wssa.net/wssa/weed/surveys/.

Florpyrauxifen-benzyl + Aminopyralid with Flumioxazin + Pyroxasulfone for Non-Crop Weed Control in U.S. Land Management. William L. Hatler*[1], Byron B. Sleugh[2], Scott Flynn[3], Sam Ingram[4]; [1]Corteva Agriscience, Meridian, ID, [2]Corteva Agriscience, Carmel, IN, [3]Corteva Agriscience, Lees Summit, MO, [4]Corteva Agriscience, Savannah, GA (251)

TerraVue® Herbicide (Rinskor™ + aminopyralid) is a new herbicide developed by Corteva Agriscience for control of broadleaf weeds, including invasive and noxious weeds, and certain woody plants in non-crop areas. Piper EZ herbicide (flumioxazin + pyroxasulfone) is a new suspension concentrate formulation with activity on select grass and broadleaf weeds in non-crop and bare ground sites. Extensive research with the combination of TerraVue 129-259 g ai/ha + Piper EZ 532 g ai/ha was conducted on non-crop/bare ground weed control across the U.S. in 2020-2021. Trials were predominantly applied pre-emergent in the fall of 2020 or spring 2021, with some early post-emergent applications in early summer 2021. Results indicate overall excellent in-season control of key annual grasses such as downy brome (Bromus tectorum L.), foxtails (Setaria spp.), wild oat (Avena fatua), and Italian ryegrass (Lolium multiflorum). Excellent control was also observed on kochia (Kochia scoparia), shortpod mustard (Hirschfeldia incana), Russian thistle (Salsola iberica), and field bindweed (Convolvulus arvensis). Late-season mean control at 15-17 weeks after application (WAA), across all grass and broadleaf weeds tested, was 77% for TerraVue 129 g ai/ha + Piper EZ 532 g ai/ha versus 82% for industry standard Method 140 g ae/ha + Esplanade 73 g ai/ha. Mean bare ground at 15-17 WAA was 77% for TerraVue 129 g ai/ha + Piper EZ 532 g ai/ha versus 71% for Method 140 g ae/ha + Esplanade 73 g ai/ha. Based on these results, TerraVue + Piper EZ will be a very effective combination for broad-spectrum annual grass and broadleaf control in non-crop and bare ground vegetation management. ™® Trademarks of Corteva Agriscience and its affiliated companies.

Florpyrauxifen-benzyl Plus Aminopyralid as a Foundation Herbicide for Total Vegetation Control in Industrial Land Management. Cody J. Chytyk[1], Laura Smith*[2], Rory Degenhardt[3], Jamshid Ashigh[4], Kevin G. Falk[5]; [1]Corteva Agriscience, Saskatoon, SK, Canada, [2]Corteva Agriscience, West Lorne, ON, Canada, [3]Corteva Agriscience, Edmonton, AB, Canada, [4]Corteva Agriscience, London, ON, Canada, [5]Corteva Agriscience, Oak Bluff, MB, Canada (252)

Florpyrauxifen-benzyl (Rinskor™ active), a new Group 4 chemistry in the arylpicolinate family, and aminopyralid, a group 4 chemistry in the pyridine carboxylic acid family, have been developed into a new wettable granule (WG) premix formulation being commercialized as Milestone® NXT herbicide in Canada (60% w/w aminopyralid + 4.7% w/w Rinskor). Trials were conducted in 2019 and 2020 across Manitoba, Saskatchewan, and Alberta to determine if kochia (*Bassia scoparia*) control was improved when Milestone NXT at 129 g ae/ha was combined with the broad-spectrum bareground product Torpedo (42.5% w/w pyroxasulfone + 33.5% w/w flumioxazin) at 319 g ai/ha. Results showed that kochia control was improved with the addition of Milestone NXT to Torpedo, in some instances by as much as 49% compared to Torpedo applications alone. The duration of control was also extended when the two products were combined relative to application of individual products, with control still observed 11-14 weeks after application. The Milestone NXT and Torpedo tank mix provides broad-spectrum weed control, including enhanced kochia activity, providing applicators and land managers with a new tool to manage hard to kill and herbicide resistant weeds on industrial land.

Finding a Fit for Florpyrauxifen-benzyl-containing Herbicides in Pastures and Hayfields.
Wykle C. Greene*[1], Michael L. Flessner[1], Scott Flynn[2]; [1]Virginia Tech, Blacksburg, VA, [2]Corteva Agriscience, Lees Summit, MO (253)

Florpyrauxifen-benzyl is a synthetic auxin herbicide that is contained in two products as a premix herbicide of florpyrauxifen-benzyl + 2,4-D and florpyrauxifen-benzyl + aminopyralid. Florpyrauxifen-benzyl + 2,4-D expected to for commercial release in 2022 and is reported to preserve established white clover, something that is not currently offered by any labeled herbicide in pastures and hayfields. Florpyrauxifen-benzyl + aminopyralid is currently labeled in pastures and hayfields where it is reported to control many common and troublesome weed species. Field trials were conducted throughout Virginia in order to determine how these herbicides fit into weed management programs in forage systems in Virginia. Research evaluated: broadleaf weed control, the effect of herbicides on hayfield composition, and the tolerance of forage crops during establishment. Trials evaluating broadleaf weed control demonstrated that both florpyrauxifen-benzyl + 2,4-D and florpyrauxifen-benzyl + aminopyralid were effective in controlling several broadleaf weed species, however florpyrauxifen-benzyl + aminopyralid was more effective in controlling certain weed species such as horsenettle. Hayfield composition trials showed that both herbicides resulted in increased forage grass biomass and decreased broadleaf weed biomass, however, while florpyrauxifen-benzyl + 2,4-D did decrease forage legume biomass compared to the nontreated control, florpyrauxifen-benzyl + 2,4-D was the only herbicide that did not eliminate white clover. Forage establishment trials showed that tall fescue and orchardgrass establishment was not affected by either florpyrauxifen-benzyl + 2,4-D or florpyrauxifen-benzyl + aminopyralid, regardless of application timing around the time of establishment. However, results for white clover establishment were mixed. Drilled white clover establishment was not affected by any herbicide treatment made the fall prior to spring seeding. Aminopyralid-containing treatments did reduce or prevent white clover establishment to both drill and frost-seeded white clover. This research demonstrates the usefulness of florpyrauxifen-benzyl-containing herbicides in pastures and hayfields through effective weed control, increased forage production, and utility around the time of forage establishment. The specific application techniques regarding these herbicides will be site specific, and future research is needed to further investigate their utility across differing environments.

East Texas Sandbur Control: A Two Decade Meta-analysis. Zachary S. Howard*, Scott A. Nolte; Texas A&M University, College Station, TX (254)

Sandbur (Cenchrus spp.) are a group of native and non-native weed that is problematic due to its sharp burs found on its inflorescences. These plants have the ability to cause serious injury to livestock, displace valuable forage, and be difficult to control once established. *Cenchrus* spp. typically found in East Texas include *C. echinatus*, *C. spinifex*, and *C. longispinus*, though others have been reported. The traditionally recommended management strategy of broadcast herbicide applications pre-emerge (pre), post-emerge (post) or a combination thereof are typically expensive, require meticulous scouting for proper weed size at application, and are variable in their efficacy. Thus, learning from the efficacy of past research trials conducted in East Texas can help guide future research efforts for the development of better management recommendations. Data from previously conducted herbicide trials were aggregated and sorted by timing to the weed of pre, post, and their combination. Overall, 30 trials were included and over 50 unique treatments observed. This research highlights that we are at most only achieving suppression with previously observed treatments. Thus, there is a need for; multiple applications regardless of application timing to the weed, herbicides that can offer both pre and post activity, a focus on incorporating additional management strategies, and long-term trials to monitor population declines or increases.

Beyond the Dead Weed - Collaborating to Capture and Share the Benefits of Managing Vegetation to Meet Wildlife, Pollinator and Other Habitat Objectives. Byron B. Sleugh*[1], Charles Hart[2], Scott Flynn[3], Travis Rogers[4], William L. Hatler[5], Sam Ingram[6], Mark J. Renz[7], Brian A. Mealor[8], Timothy S. Prather[9], Jane Mangold[10]; [1]Corteva Agriscience, Carmel, IN, [2]Corteva Agriscience, Abilene, TX, [3]Corteva Agriscience, Lees Summit, MO, [4]Corteva Agriscience, Charleston, SC, [5]Corteva Agriscience, Meridian, ID, [6]Corteva Agriscience, Indianapolis, IN, [7]University of Wisconsin-Madison, Madison, WI, [8]University of Wyoming, Laramie, WY, [9]University of Idaho, Moscow, ID, [10]Montana State University, Bozeman, MT (256)

Weed scientists often focus mainly on efficacy in their vegetation management projects and many other important questions that may be of concern to a broader cross-section of stakeholders are sometimes not fully addressed. It is important therefore to look beyond the dead weed and focus on collaborating with others to capture and share the benefits of managing weeds to meet a variety of stakeholder objectives including wildlife, pollinator, or other habitats, or grazing animal production. Collaborative research and/or demonstration projects were initiated with private landowners, university, Local, State, and Federal Agencies, NGOs, and industry partners utilizing various weed management tools in diverse environments across the US. These multi-year, multi-partner collaborations have focused on topics beyond efficacy of herbicides but have focused on topics including but not limited to – response of native forbs, shrubs or trees to herbicide applications, pollinator habitat effects, wildlife response to the control of invasive annual grasses, habitat improvements through weed/brush management, forage response, and long-term ecosystem response to weed or brush control. The study sites include wildlife management areas, utility right of ways, roadsides, conservation or working (grazed) grasslands, National Forests, and others. Outcomes from these projects are currently being communicated or will be communicated to stakeholders through a variety of channels including professional meetings, extension bulletins, informational publications, landowner/land manager meetings, and other venues to help provide site-specific management information to better meet land manager objectives. The summary of these projects shows the importance of multi-year, multi-partner collaborative projects in providing information to land managers and the broader community.

Oral 05. Regulatory Aspects

An Overview of the Paraquat Registration Review Interim Decision Requirements for Paraquat Containing Products: What Does That Mean for the End-User and Registrant.
Montague U. Dixon*; Syngenta Crop Protection, Greensboro, NC (259)

AN OVERVIEW OF THE PARAQUAT REGISTRATION REVIEW INTERIM DECISION REQUIREMENTS FOR PARAQUAT CONTAINING PRODUCTS: WHAT DOES THAT MEAN FOR THE END-USER AND REGISTRANT ABSTRACT Paraquat containing herbicide products are important elements of integrated weed management programs associated with conventional and genetically modified crops. Furthermore, paraquat is extremely important where glyphosate resistance in weeds has been identified and is also an essential component in delaying the development of resistance to glufosinate in crops that are designed to tolerate that herbicide. Additionally, but no less important, paraquat is a critical tool in reduced and no-till farming which leads to reduced soil erosion and a significantly reduced carbon footprint when compared to conventional cultivation. On August 2, 2021, the United States Environmental Protection Agency issued the Paraquat Dichloride Interim Registration Review Decision that specified required changes for the continuing registration of paraquat containing products. These changes included but are not limited to label changes including standardization of label metrics, updating certain PPE requirements, revising re-entry intervals, and establishing acreage restrictions for aerial applications. Paraquat registrants were required to submit revised labelling that incorporated the requirements of the Paraquat Interim Decision by October 1, 2021. The affected product labels that have been submitted are in review at the Environmental Protection Agency and are anticipated to be approved in the near future.

Enlist Herbicides Label Update. David M. Simpson*[1], Reuben Baris[2], Byron B. Sleugh[3], Tammie Jones-Jefferson[1]; [1]Corteva Agriscience, Indianapolis, IN, [2]Corteva Agriscience, Indianapollis, IN, [3]Corteva Agriscience, Carmel, IN (261)

Recently in a press release, the U.S. Environmental Protection Agency (EPA) stated their new Endangered Species Act (ESA) protection policy for new pesticides. On January 11, 2022, EPA completed the registration amendment process for Enlist Duo® (2,4-D choline + glyphosate) and Enlist One (2,4-D choline) herbicides representing the first registrations utilizing the new policy. Both Enlist One and Enlist Duo received a seven-year registration through January 11, 2029. During the amendment process, EPA conducted updated data analysis and appropriate agency consultations to help confirm Enlist One and Enlist Duo herbicides continue to comply with the ESA, and the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). As part of that process, EPA updated its ecological and ESA risk assessments, resulting in the addition of targeted risk mitigation measures to the Enlist herbicide labels. The new Enlist One and Enlist Duo herbicide labels contain new required runoff mitigations and new county restrictions specifically to address protection of endangered species and their habitats. Runoff mitigation requirements emphasize the utilization of cultural and agronomic practices to reduce potential for runoff. These include, but are not limited to, reducing number of applications of Enlist herbicides, residue management through use of reduced- or no-tillage practices, and the utilization of field borders, field buffers, grassy waterways, contour buffer strips or terraces. To mitigate potential risks to pollinators, the application timing in soybean has changed to any time after soybean emergence through the R1 growth stage and in cotton from emergence up to first white bloom. Other label changes were implemented to improve communication of product use directions or to enhance ability to update specific recommendations such as updating list of approved nozzles. The new registrations will ensure that growers can continue to utilize the Enlist weed control system to control weeds in corn, cotton and soybean containing the Enlist traits.

Governing Weed Science: Takeaways from the Science Policy Fellowship Experience.
Rebecca Champagne*[1], Devon E. Carroll[2], Lee Van Wychen[3]; [1]University of Maine, Orono, ME, [2]University of Tennessee, Knoxville, TN, [3]Weed Science Society of America, Alexandria, VA (263)

Educating stakeholders and the general public on the impact of weeds across different ecosystems is an important goal in the weed science discipline. Policy makers and government officials can have a large influence on the allocation and regulation of funding and resources for weed research and management, making their knowledge of weed science of great importance. The Weed Science Society of America's (WSSA) Science Policy Committee strives to make the expertise of the national and regional weed science societies known and readily available to Congress, Federal Agencies, non-governmental organizations (NGO's), and other scientific societies. Young weed scientists are interested in science policy but often lack exposure and experience with the federal science policy process. The WSSA Science Policy Fellowship provides an experiential learning opportunity for graduate students to assist the Executive Director of Science Policy, Dr. Lee Van Wychen, while gaining experience with weed science policy issues. This past year, Rebecca Champagne from the University of Maine and Devon Carroll from the University of Tennessee were awarded Science Policy Fellowships and participated in various weed science policy activities. Due to COVID-19, experiences were limited to a virtual format. The Science Policy Fellows represented WSSA by analyzing results from the national survey for the most common and troublesome weeds and helped draft questions for the upcoming research priorities survey. Additionally, Rebecca and Devon aided the science policy mission by scheduling and participating in meetings with congressional staff from North Dakota, South Dakota, North Carolina, Colorado, Kansas, and Tennessee along with the weed science society presidents to discuss pertinent issues facing weed science. During this fellowship, Rebecca and Devon learned the importance of connecting with government officials and advocating for weed science, and were made aware of the funding opportunities available to weed scientists. The fellowship provided a unique opportunity to experience a broad array of weed science policy issues and better understand the intricacies of science policymaking and communications at the federal level.

Oral 06. Teaching and Extension

CAST At 50 Years: Where to from Here? Jill Schroeder*[1], Gregory K. Dahl[2], Lyn A. Gettys[3], John Hinz[4], Hilary A. Sandler[5]; [1]New Mexico State University, Las Cruces, NM, [2]Winfield United, Eagan, MN, [3]University of Florida, Davie, FL, [4]Bayer Crop Science, Story City, IA, [5]UMass Cranberry Station, East Wareham, MA (264)

Since 1972, the Council for Agricultural Science and Technology (CAST) has provided credible, unbiased, science-based information about food and agriculture to policy makers, the media, the private sector, and the public. WSSA was a founding member of CAST and, currently, the WSSA representative is a member of the CAST Board of Representatives. The Board of Representatives is made up of representatives from member societies, universities, commercial companies, nonprofit or trade organizations, and the Board of Directors. Each member of the board serves on one of three work groups—Animal Agriculture and Environmental Issues, Food Science and Safety, or Plant Agriculture and Environmental Issues. The work groups meet at an annual board meeting and hold monthly conference calls. Weed science is well represented on the CAST Board of Representatives Plant Agriculture and Environmental Issues workgroup with members from WSSA, NEWSS, NCWSS, WSWS, and APMS. As part of the 50-year commemoration, CAST has refined the strategic plan through development of an adaptive plan based on stakeholder feedback. The goal of the planning is to build on previous success but work to become more flexible and to adapt to address the feedback from stakeholders. We, as board representatives, welcome input from the members of our organizations on how CAST can enhance communication of science to more audiences and on topics of concern that need to be addressed through CAST publications.

Glyphosate Education and Emerging Environmental Issues in Florida. Stephen F. Enloe*; University of Florida, Gainesville, FL (265)

Since the development of genetically modified herbicide- tolerant crops, glyphosate has become the most widely used herbicide in the world. The science regarding its environmental fate and safety have been widely accepted for decades. However, a recent reclassification of glyphosate potential carcinogenicity by the International Agency for Research on Cancer and subsequent lawsuits alleging health issues have raised significant concerns across the globe. This has prompted several bans on glyphosate use including some cities and counties in Florida. While the EPA has maintained that glyphosate is not likely to be a carcinogen, the collective impact of these actions has resulted in a need for new glyphosate educational efforts for pesticide applicators, land managers, policy makers, and the general public. This presentation will focus on how UF/IFAS is leading the effort to present the science of glyphosate to a broad range of clientele and address recent environmental issues including glyphosate detection in West Indian manatees.

2021 Georgia Pesticide Application Equipment & Technology Survey. Eric P. Prostko*, Simerjeet Virk; University of Georgia, Tifton, GA (266)

Georgia is a leading producer of numerous crops including cotton, peanut, blueberries, pecans, bell peppers, cabbage, watermelons, and peaches. Pesticide applications are critical to the successful production of these crops. In 2021, online and printed pesticide application/technology surveys, created in Qualtrics®, were sent to Georgia county extension agents in 159 counties. County extension agents e-mailed and texted online survey links to growers and distributed printed copies at other face-to-face meetings. A total of 186 responses, approximately 50/50 split between online/printed surveys, from 65 counties were received. Top 10 highlights from the survey responses were as follows: 1) 72% of respondents produced = 500 acres of crops annually; 2) 29% of respondents received their information from University Extension; 3) 42% of respondents used a separate sprayer for applying dicamba, 2,4-D, or 2,4-DB; 4) 46% of respondents used sprayers with boom lengths = 61 feet; 5) 65% of respondents used = 13 GPA when applying herbicides; 6) 53% of respondents have 3 or more different nozzle types on their spray booms; 7) 68% of respondents used TeeJet® nozzles; 8) 65% of respondents used GPS and rate controllers; 9) 66% of respondents recorded their application records on a notepad or diary; and 10) 39% of respondents reported that accuracy is the biggest advantage of new technologies. Respondents reported that drift/regulations, weather, and timing were their biggest application challenges and that they would like to see more research conducted on topics such as product rates/carrier volumes, pest control (weeds/insects/disease), and chemicals/adjuvants. Results from this survey will be useful in the development of future pesticide application research and extension programs in Georgia.

Nonchemical Strategies for Managing Herbicide-Resistant Weeds in Semiarid U.S. Great Plains: Research and Extension Needs. Vipan Kumar*[1], Rui Liu[1], Sachin Dhanda[1], Prashant Jha[2], Jason K. Norsworthy[3], Phillip Stahlman[1]; [1]Kansas State University, Hays, KS, [2]Iowa State University, Ames, IA, [3]University of Arkansas, Fayetteville, AR (267)

Rapid spread of herbicide-resistant (HR) weeds poses a serious management challenge for producers in no-tillage (NT) semi-arid regions of the U.S. Great Plains. The widespread adoption of HR crops (mainly glyphosate-resistant), repetitive use of herbicides with the same site of action, and lack of diversity in weed control practices resulted in evolved resistance to herbicides in major cropland weed species, including horseweed, kochia, Palmer amaranth, common waterhemp, and Russian thistle. For instance, glyphosate resistance in kochia and Palmer amaranth has widely spread in the central and southern Great Plains. Managing HR weeds is complex and varies both within and between regions. Nonetheless, increasing herbicide costs to manage these HR weeds in combination with low commodity prices necessitates the development of ecologically benign, alternative weed control strategies in the region. Several nonchemical strategies, including cover crops, occasional/strategic tillage, alteration in agronomic practices, and harvest weed seed control (weed seed destruction and chaff lining) have shown promising results in managing HR weeds in recent years. This paper aims to highlight the role of these nonchemical strategies for HR weed control in U.S. Great Plains, with emphasis on ecological, economic, and agronomic benefits. We will also illustrate current research gaps and propose new research and outreach needs for their adoption in the region.

Agricultural Sustainability and Denial. Robert L. Zimdahl*; Colorado State University, Fort Collins, CO (268)

A simple definition of sustainable agriculture is: farmers should farm so they can farm again. It must be an agricultural system that evolves indefinitely toward greater human utility, greater efficiency of resource use, and a balance with the environment favorable both to humans and other species. There are many definitions and each includes value-laden words: quality, enhance, respect, utility, efficiency, balance, and favorable. Most definitions are <u>ego</u>centric - land is an instrument to achieve human ends, not <u>eco</u>centric - land has inherent value. Nature's needs - care for the land - must be coincident with not separate from human wants and needs. Nature, humans, and other species should be sustained. Sustaining and improving agricultural production is a good thing but it cannot always be the highest value. When agricultural technologies pollute water, harm non-target species, or contaminate food, it becomes difficult to argue that public support for production and profit should always be maintained and increased. A sustainable agricultural system should conserve resources, achieve high energy outputs given its energy inputs, provide sufficient, safe food for people, and be profitable. In spite of the lack of a precise definition it is implied by agriculture's regular use of words such as environment, conserve, restore, and preserve. Sustainability is a goal all involved in agriculture support. strive to achieve and agree it is good, worthy objective.

Oral 07. Formulation, Adjuvant, & Application Technology

Positive and Negative Herbicide and Adjuvant Interactions with Quizalopfop-p-ethyl. Richard K. Zollinger*[1], Joseph A. Bruce[2], Kirk A. Howatt[3], Peter Porpiglia[4]; [1]AMVAC Chemical Corporation, Spokane Valley, WA, [2]AMVAC Chemical Corporation, Glen Carbon, IL, [3]North Dakota State University, Fargo, ND, [4]AMVAC Chemical Corporation, Newport Beach, CA (271)

Field research was conducted at eight locations in 2019, 28 locations in 2020, and 32 locations in 2021 to evaluate grass efficacy from quizalofop-P-ethyl ester applied in combination with atrazine, dicamba, imazaquin, glufosinate, mesotrione, topramezone, or dicamba and 2,4-D in three types of spray quality. Crop oil adjuvant was added at 1% v/v. Ammonium sulfate was added to evaluate enhancement affect with some herbicides. Treatments were applied to natural grass weed populations or to assay species of corn, wheat, barley, oat, sudan, sorghum, or tame millet planted in strips across each replication perpendicular to each plot. Atrazine at 0.6, 1.1, and 2.2 kg/ha did not reduce grass control when applied with quizalofop at 31, 47, and 62 g/ha. Glufosinate at 460, 606, and 669 g/ha was neutral or reduced grass control when applied with quizalofop at 16, 31, 47, 62 and 94 g/ha. Increasing the rate if quizalofop overcame the reduction in grass control. Mesotrione at 107 g/ha did not reduce grass control when applied with quizalofop at 47 g/ha. Topramezone at 13, 19, 25, and 50 g/ha did not reduce grass control when applied with quizalofop at 31, 47, 62 and 94 g/ha. Volunteer corn and grass weeds germinated, emerged, were visibly stunted, and were not completely controlled by rain-activated imazaquin applied PRE at 50, 72, 105 g/ha. Quizalofop applied sequentially postemergence at 31 g/ha to the same imazaquin treatments completely controlled volunteer corn and grass weeds at the same or greater level as quizalofop applied alone. In medium (M) to coarse (C) spray quality, grass crop species of corn, wheat, barley, and oat control were not reduced or slightly reduced by 2,4-D-choline applied with quizalofop at 63 g/ha. No quizalofop antagonism was observed when applied 1 day before 2,4-D and grass control was similar to quizalofop applied alone. Grass weed control from quizalofop applied 1 day before 2,4-D was 91 to 99% but when applied together grass control was 62 to 74%. Increasing the quizalofop rate from 63 to 94 g/ha did not overcome the reduction in grass control. Increasing the rate of 2,4-D from 0.8 to 1.1 kg/ha did not further reduce grass control. Addition of AMS did not overcome antagonism from 2,4-D or increase grass control. Averaged across 6 locations, as droplet size increased from M, C, to extremely coarse (XC) spray quality grass control from quizalofop applied at 47 g/ha significantly decreased from 88%, 84%, to 63%, respectively. 2,4-D or dicamba applied with quizalofop in XC spray quality reduced grass control to a greater level than the same treatment at M or C spray quality. Reduction in grass weed control was much greater from quizalofop mixtures with 2,4-D than dicamba. Quizalofop at 63 g/ha was required to overcome volunteer corn control reduction from the addition of dicamba at 0.56 kg/ha or 2,4-D at 0.8 or 1.1 kg/ha while the highest rate of quizalofop at 94 g/ha did not overcome the reduced grass weed control from 2,4-D. This may be due to the combined effect of using large spray droplets (XC) with the greater antagonism potential from 2,4-D. Barnyardgrass, yellow foxtail, and crabgrass are species which may express dicamba and 2,4-D antagonism of quizalofop to a much greater level than other grass weed species. Prediction of reduced grass control when a particular broadleaf herbicide is added to quizalofop is difficult because antagonism or lack of is influenced by specific grass specie, size and age of the grass weed, type and rate of both the grass and broadleaf herbicide, stress on the grass plant, environment type, as well as water, spray, and adjuvant quality.

Introducing UltraLock™, a Novel Deposition and Drift Reducing Adjuvant. Gregory K. Dahl*[1], Ryan J. Edwards[2], Ryan Wolf[3], Joshua Mayfield[4], Joshua J. Skelton[5], Steven A. Fredericks[2], Christine Colby[2], Eric P. Spandl[6], Kevin Krueger[7]; [1]Winfield United, Eagan, MN, [2]WinField United, River Falls, WI, [3]Winfield United, Sheldon, IA, [4]Winfield United, Four Oaks, NC, [5]WinField United, Saint Paul, MN, [6]Winfield United, Shoreview, MN, [7]Winfield United, Arden Hills, MN (272)

Winfield United developed UltraLock™, a new adjuvant product that combines the functions of drift reduction technology, DRT, adjuvants with the functions of drift reduction adjuvants, DRA. DRT adjuvants were convenient to use and effective for increasing deposition, coverage, and canopy penetration, while reducing off-target particle drift with many herbicides. DRT adjuvants did not reduce spray particle drift sufficiently when used alone with the new dicamba formulations and nozzles. DRA adjuvants were developed for use with the new dicamba formulations and nozzles required, but they were viscous, inconvenient to handle, and had coverage limitations. Winfield United determined that spray particle drift could be further reduced by tank mixing DRT adjuvants with DRA adjuvants. This required two products to be added to the spray mixture. UltraLock was developed to combine the DRA adjuvant technology with the DRT technology into a single product. Research was conducted in wind tunnels, laboratories, greenhouses and in the field to determine droplet sizes, deposition and coverage and field performance. Spray analysis demonstrated that UltraLock reduced the volume and number of small driftable spray droplets more than with a DRA adjuvant alone and similar to a DRA plus DRT adjuvant system. Laboratory studies demonstrated that UltraLock was compatible with many herbicide spray mixtures and product poured quicker, more easily and more completely than DRA adjuvants. Greenhouse and field studies determined that deposition, spray coverage and herbicide performance were improved compared to herbicide alone and was better than or equal to performance of herbicide plus commercial adjuvants.

The Utility of Soil Adsorption Agents for Improving Residual Herbicide Retention in Sandy Soils. Ramdas Kanissery*; University of Florida, Immokalee, FL (273)

Southwest Florida is considered a primary production hub for vegetable production in the state. Sandy soils, high annual rainfall and year-round warm weather promote weed growth, creating weed management challenges for the producers in the region. In addition, these soil and weather conditions cause undesired movement and rapid leaching of residual herbicides applied to manage weeds from the 'weed activity zone' onto non-target areas resulting in poor weed suppression and inadvertent crop effects. Hence, in the current study, residual herbicides were combined or tank-mixed with adjuvants like soil adsorption or binding agents to improve such weed management constraints. Field studies were conducted at Immokalee, FL, to evaluate the potential of soil adsorption agents to enhance the retention of residual herbicides like flumioxazin, pendimethalin and s-metolachlor to improve their efficacy and crop safety in raised bed vegetable plasticulture production. Compared to using residual herbicide alone, the combination of herbicides with soil adsorption agents tested in this study exhibited a significantly longer duration of weed suppression in the vegetable row middles. Moreover, when herbicide products were applied with adsorption agents on the raised beds, it reduced the movement of herbicide-active ingredients into the planting holes, thereby improving the crop safety as observed from the enhanced plant vigor and greenness of the tomato transplants.

Sand Abrasion and Herbicide Application Effects Controlling Brazilian Peppertree (*Schinus terebinthifolia*). Shawn T. Steed*[1], Chris Oswalt[2]; [1]University of Florida, Seffner, FL, [2]University of Florida, Bartow, FL (276)

Brazilian peppertree (BP) is an evergreen, small tree/large shrub that grows to 10m (30 ft). It is native to Brazil, Argentina, and Paraguay and has become an invasive species in areas of south and central Florida. Removal can be difficult with mature plants using broadcast postemergence spray, hack-and-squirt, and cut stump/herbicide application. A novel method of brush control using existing, low-cost technology in sandblasting abrasives and pressure washing machinery to open the plant's vascular system to herbicide for increased uptake and control was conducted. The experimental design was a randomized controlled block design with five blocks and five treatments. Multi-trunk BP trees were selected with stems ranging from 1.5 to 3-inch diameter. Treatments were: 1 Cut stump (CS); 2 Abrasion+Herbicide (AH); 3 Herbicide only (H); 4 Abrasion only (A); and 5 an untreated control (C) treatment. Herbicide treatments consisted of 100% glyphosate applied with a battery-powered backpack sprayer at about 65 psi. The CS herbicide was applied with a foam brush to the cut surface. CS is one of the current University of Florida recommendations for Brazilian pepper removal. Plant health visual observations were collected at 4, 8, 12, 16, and 24 weeks after treatment (WAT) and rated on a quantitative scale of 1=no plant injury to 10 = no visible life, dead. The experiment started on October 24, 2019, and was repeated on June 10, 2020, to determine if seasonality influenced control. There were no significant interactions by season, season by treatment, season by WAT, and season by treatment by WAT so means were combined for comparisons. Treatments effects were highly significant at each time comparison starting at 4 WAT. CS and AH treatments had significantly greater control ($P<0.0001$) compared to the H alone, which was significantly greater than A and the check which did not differ throughout the experiment. After 16 WAT, CS decreased in control due to sprouting and regrowth at the cut surfaces or the base of the plant which continued to grow to 24 WAT. H treatment also differed at 24 WAT due to the regrowth of treated plants. CS and AH treatments demonstrated excellent control of BP initially however CS treatments showed regrowth and sprouting from the base of the cut surface after some time. These would eventually regrow the plants. Very good control was observed with H treatments. Abrasion and herbicide combination showed an excellent control effect that continued until complete death. Further research should be done in this area to expand the use of abrasion to control large woody plants.

Spray Drift of Dicamba into Soybeans: A Comparison of Application and Measurement Methods. Tom Wolf*[1], Brian Caldwell[1], Christian Willenborg[2], Eric N. Johnson[2], Sid A. Darras[3], Ian Paulson[4]; [1]Agrimetrix Research & Training, Saskatoon, SK, Canada, [2]University of Saskatchewan, Saskatoon, SK, Canada, [3]Research Associate, Saskatoon, SK, Canada, [4]PAMI, Saskatoon, SK, Canada (277)

Field trials were conducted to better understand how accurately spray drift yield losses can be predicted with traditional spray drift studies. Dose response trials were conducted at the University of Saskatchewan Kernen Research Farm in 2018 and 2019. Herbicide treatments included Engenia (dicamba BAMPA salt), Xtendimax (dicamba DGA salt), each applied at 0, 0.000061, 0.00024, 0.00098, 0.0039, 0.0156, 0.0625, 0.25, and 1.0 X (600 g ae/ha) application rates. Herbicide treatments were applied in a RCBD design with 4 replicates when the soybeans were in the 2-3 trifoliate stage. Both forms of dicamba elicited similar LD50s. Spray drift studies were conducted near Saskatoon, SK in 2019 and 2020. Drift studies involved the application of dicamba (Xtendimax) at 600 g ae/ha plus Rhodamine WT (fluorescent tracer, analyte) at 0.25% v/v. In 2019, application was made using a John Deere R4045 sprayer with a 36 m boom equipped with LDX12004 tips operated at 550 kPa (ASABE Medium spray quality) and travelling at 27 km/h at a boom height of 60 cm. Application volume was 94 L/ha and side winds were 9 km/h. In 2020, two application were conducted using a John Deere 4830 sprayer equipped with LDX110035 tips operated at 415 kPa (ASABE Medium spray quality). The first application was at 27 km/h (66 L/ha water volume) with a 90 cm boom height and a wind speed of 16 km/h. The second application was made at 14.5 km/h travel speed (133 L/ha) with a 60 cm boom height at a wind speed of 23 km/h. In all trials, dicamba phytotoxicity was assessed using visual ratings and seed yield measurements. Drift trials additionally measured deposition on 15 cm diameter petri plates, vertical drinking straws, and soybean plants. Drift trials showed the deposited rate of dicamba at distances up to 160 m downwind. Dose response trials were used to estimate the damage expected at those rates. Actual damage shown by dicamba in the drift trials was compared to that predicted by the dose response trials. Results showed that visual ratings at 21 DAT overestimated yield losses in all studies. Dose response and drift trial yields showed similar plant responses at dosages estimated by petri plate collectors. The dose response studies tended to over-estimate yield losses compared to the drift trials in both years. Plants in the drift trial lost yield more rapidly with increased dose than in the dose response trial. Drift studies employing petri plate collectors provided overall close estimates of expected drift damage based on commensurate dose response studies.

Oral 08. Weed Biology & Ecology

Weed Suppression and Community Assembly Across Management Gradients: A Taxonomic and Trait-based Approach. Uriel D. Menalled*[1], Guillaume Adeux[2], Stéphane Cordeau[2], Richard G. Smith[3], Steven Brian Mirsky[4], Matthew R. Ryan[1]; [1]Cornell University, Ithaca, NY, [2]INRAe, Dijon, France, [3]University of New Hampshire, Durham, NH, [4]USDA-ARS, Beltsville, MD (279)

Organic no-till crop production can provide soil health benefits and use less labor and fuel than traditional, tillage-based, organic crop production. However, without synthetic herbicides or tillage, organic no-till crop production is highly dependent on effective ecological weed management. In addition to reducing weed-crop competition, ecological weed management aims to prevent the proliferation of highly adapted weed species. Weed community assembly theory is an integral part of ecological weed management and can optimize production systems by describing how different management practices filter weed traits. We quantified the effects of soybean [*Glycine max* (L.) Merr.] density and cereal rye (*Secale cereale* L.) mulch biomass on weed suppression and community assembly in an organic no-till system using a trait-based approach that assessed weed life cycle, emergence timing, seed weight, height, and specific leaf area. Total weed biomass was affected by an interaction between increased soybean density and mulch biomass, suggesting synergistic weed suppression when the two management practices were combined. Soybean density and mulch biomass also affected weed communities by constraining their trait functional dispersion and shifting mean trait values. Increased mulch biomass had a larger effect on annual weed suppression and more consistently filtered weed community traits than soybean density. However, increased soybean density reduced perennial weed biomass and may be an effective strategy for managing perennial weeds. Results illustrate the potential for weed community assembly theory to help guide ecological weed management and enable farmer adoption of organic no-till crop production.

Introducing the Critical Period for Weed 'Seed' Control. Charles M. Geddes*[1], Adam S. Davis[2]; [1]Agriculture and Agri-Food Canada, Lethbridge, AB, Canada, [2]University of Illinois, Urbana, IL (280)

Increasing herbicide-resistant weed issues globally warrants reevaluation of fundamental weed control objectives. While the mitigation of crop yield loss remains critically important, reducing the proliferation of herbicide-resistant weeds warrants limiting their seed from returning to the soil seedbank. The critical period for weed 'seed' control (CPWSC) builds upon the well-accepted concept of the critical period for weed control, or the period of crop growth and development during which the crop must remain weed-free in order to avoid unacceptable yield losses. Instead, the CPWSC shifts the focus away from the crop and on to problematic weed species. The CPWSC is the period of the growing season during which weed management can mitigate unacceptable weed seed production and return to the soil seedbank. The CPWSC provides a framework to target problematic weeds during phenological stages critical for seed development. Like the critical period for weed control, the CPWSC is derived from overlapping two component curves: (i) the critical period for weed emergence, and (ii) the critical period for seed production. An example data set for kochia [*Bassia scoparia* (L.) A.J. Scott] in Lethbridge, Alberta, revealed that kochia seed production could be reduced by 99% (1% seed threshold) by targeting weed management during a ~4-day window between 2056 and 2120 growing degree days (GDD; T_{base} 0°C), coinciding with the third week of August. A 95% reduction in kochia seed production could be achieved by targeting a wider 3-week window between 1867 and 2220 GDD. The CPWSC provides a robust framework to limit weed seed production and return to the soil seedbank through phenology-based weed control. This session aims to (i) introduce the CPWSC concept, (ii) provide a real-world example, (iii) discuss the benefits and shortfalls of this methodology, and (iv) offer a glimpse into its utility for practical weed management.

The Role of Hydrochory in Bohemian Knotweed (*Reynoutria x bohemica*) Seed Dispersal and Seedling Establishment. Maria Goncharova*[1], David R. Clements[2]; [1]Trinity Western University, Surrey, BC, Canada, [2]Trinity Western University, Langley, BC, Canada (284)

Identifying factors involved in invasive species dispersal is crucial in understanding how to prevent and manage further invasion. Hydrochory allows for long-distance dispersal and provides new habitats for plants. Indeed, *Reynoutria x bohemica* (Chrtek & Chrtková), one of the world's worst invasive weeds, has been frequently observed near water bodies providing circumstantial evidence for the importance of hydrochory. Bohemian knotweed is of particular interest among other *Reynoutria spp* as it has vigorous regeneration ability, higher genetic diversity, and is more difficult to control. It exhibits its parents' best properties: Japanese knotweed's (*Reynoutria japonica* Houtt.) extensive growth from rhizomes and giant knotweed's (*Reynoutria sachalinensis* (F.Schmidt) Nakai) viable seeds. Several studies have been conducted on the ability of knotweed seeds and seedlings to remain viable in water for a number of days, but there still exists a knowledge gap on the influence of abiotic factors on water dispersal and thereafter, establishment in soil. In this study, we examined the effects of current speed, seed morphology, and seedling growth stage on the probability of downstream establishment. We found that seedlings grown in high current levels had the highest growth rates both within aquatic systems and post establishment in soil compared to seeds grown in no current or directly in soil ($p<0.001$). There was also significant variation in seed morphology which influenced the duration of floatation thereby affecting the probability of deposition and dispersal distance. Lastly, seeds planted in soil after exhibiting cotyledons had a higher length ($p<0.05$) and biomass ($p<0.05$) growth while seeds planted after germinating had higher leaf growth ($p<0.01$). Overall results also displayed significant differences between knotweed seeds taken from different sites; thus, demonstrating that genetic variation plays a role in hydrochory success. These results provide new insight into *R.bohemica* seeds' high potential for water dispersal and downstream establishment, underlining a need for increased monitoring and management strategies near water sources.

Leaf Morphology Variation in Knotweed (*Reynoutria*) Species in Relation to Interspecific Hybridization. David R. Clements*[1], Micaela Janse van Rensburg[1], Alida Janmaat[2], Vanessa L. Jones[1], Virginia V. Oeggerli[1], Matthew G. Strelau[1], Shicai Shen[3], Bo Liu[4], Guangzhong Zhang[4]; [1]Trinity Western University, Langley, BC, Canada, [2]University of the Fraser Valley, Abbotsford, BC, Canada, [3]Key Laboratory of Green Prevention and Control of Agricultural Transboundary Pests of Yunnan Province, Agricultural Environment and Resource Research Institute, Yunnan Academy of Agricultural Sciences, Kunming, China, [4]Shenzhen Branch, Guangdong Laboratory of Lingnan Modern Agriculture; Genome Analysis Laboratory of the Ministry of Agriculture and Rural Affairs; Agricultural Genomics Institute at Shenzhen, Chinese Academy of Agricultural Sciences, Shenzhen, China (285)

Reynoutria japonica, Japanese knotweed, is an herbaceous perennial of the family Polygonaceae and is highly invasive in its introduced range of Europe and North America. Fertilization with the related *Reynoutria sachalinensis* (Giant knotweed) produces *Reynoutria x bohemica* (Bohemian knotweed), resulting in increased genetic variability and invasiveness. Morphologically, *R. x bohemica* is intermediate to *R. japonica* and *R. sachalinensis*, but backcrossing has made identification among species difficult. In this study, leaf morphology variation of knotweed in the Fraser Valley of British Columbia, Canada, is assessed. Leaf tip, trichome, base, and length morphology were evaluated using a scoring system developed by Gammon and colleagues revealing that *R. x bohemica* samples share many traits with *R. japonica*, indicating introgression. Hierarchical cluster analysis of leaf morphology revealed a distinctly *R. sachalinensis* cluster, but no such cluster for *R. japonica* or *R. x bohemica* samples, further illustrating their similarity. A DNA analysis of the chloroplast Ribulose-1,5-bisphosphate carboxylase/ Oxygenase Large Subunit (*rbcL*) gene sequence for these populations yielded a similar pattern, with two clades, one associated with *R. japonica* including several putative *R. × bohemica* populations and a second group showing considerable overlap among putative *R. × bohemica* and *R. sachalinensis* samples. Interestingly, one population appearing to be *R. sachalinensis* according to leaf morphology was part of the first cluster according to the *rbcL* sequence. Both the morphological and genetic analysis reveal a high degree of hybridization in the region. False identification of knotweed due to this similarity is significant for management, as different species respond variably to different control methods. Furthermore, the high genetic and morphological similarity of *R. japonica* and *R. x bohemica* specimens in this region may have implications for the feasibility of biological control via the psyllid *Alphalara itadori* across species, an agent presently being tested in confined trials in western Canada. Future efforts to identify knotweed in the Fraser Valley for management ought to assess as many traits as possible, and focused control of *R. sachalinensis* will be important to prevent further hybridization and the production of novel invasive genotypes.

Climate Effects on Aquatic Regeneration of Bohemian Knotweed (*Reynoutria* x *bohemica*) Rhizome and Stem Fragments. Hannah Grace Merritt*, David R. Clements; Trinity Western University, Langley, BC, Canada (286)

Knotweeds (*Reynotria* spp.), among the world's most invasive weeds, are particularly apparent along roads, railways, and waterways. Bohemian knotweed (*Reynoutria* x *bohemica*) is of particular concern, as its ability to successfully regenerate and its high genetic diversity leads to high rates of successful establishment in non-native habitats. The spread of the taxa is mainly vegetative, through rhizome and stem fragments as small as 0.7 grams. These rhizome and stem fragments are buoyant and are often spread through river or stream systems and deposited on land where they can regenerate. Limited studies have been done on the correlation between hydrochory and the effectiveness of Bohemian knotweed fragment regeneration. An added element to the invasion of Bohemian knotweed fragments is the ever-changing environment presented by climate change. Previous studies in Quebec and France have found that increased temperatures introduced by climate change encourage the growth of Bohemian knotweed populations. The present study first focused on the impact that water immersion has on Bohemian knotweed rhizome fragments, with the specific water immersion periods of 0 days, 15 days, and 30 days prior to deposition being studied. The results suggested that immersion in water prior to deposition was beneficial, with a 15-day immersion period allowing for the most regrowth in rhizome fragments. The impact of temperature on immersed rhizome regeneration rates was subsequently investigated, with a 15-day immersion period utilized. Rhizomes stored at 5 °C had a regeneration rate that was statistically higher than the other treatments of -20 °C, 23 °C, and 32 °C. This may imply that rhizomes are more likely to regenerate in spring following a cold, overwintering period, a discovery that has implications for knotweed management near riverbanks. Further experiments also suggested that higher than average temperatures promote rapid rhizome fragment growth, although more research must be done to determine the mechanisms that govern this growth. Together these findings provide insight into the role hydrochory plays in successful rhizome regeneration, as well as the risks of increasing invasion we are facing with changes in global temperatures.

Can Satellites See Kochia from Space? Thuan Ha[1], Steve Shirtliffe*[2], Eric Johnson[3], Hema Duddu[1], Steve Ryu[3]; [1]Dr., Saskatoon, SK, Canada, [2]Prof., Saskatoon, SK, Canada, [3]Mr., Saskatoon, SK, Canada (288)

Kochia is a problematic weed as it can tolerate salinity and it has evolved resistance to several herbicides including glyphosate. The use of high-resolution imagery acquired from unoccupied aerial vehicles (UAV) for weed detection and mapping has potential for small-scale field applications with high accuracy but is impractical when mapping extensive fields. Cloud-based computing platforms such as Google Earth Engine (GEE) have publicly available Landsat and Sentinel imagery data that could be used to locate Kochia patches across a large area. This study proposes an automatic Kochia mapping platform to investigate the use of satellite imagery in detecting Kochia late-growing season croplands. High resolution, ground reference data of Kochia patches were collected from 11 fields across Saskatchewan in 2021 using a multispectral sensor mounted on a UAV. Crop, weed, and kochia patches were manually interpolated to create sample data in ArcGIS Pro, and remote sensing data were collected and processed in the GEE. Data preprocessing included cloud filtering, index calculation, and pixel resampling. A time-series dataset was created, and a total of 192 predictors were used to develop three classifiers: Random Forest (RF), Classification And Regression Tree (CART), and Support Vector Machine (SVM). The results revealed that freely available satellite imagery could detect Kochia patches with an average overall accuracy of 70% and a kappa value of 0.96. The RF model outperformed other classifiers and the most important variables in the model were from Sentinel 2 satellites. The lower resolution of Landsat (spatial and temporal) and Sentinel-1 (spectral) could be a potential reason for their inefficacy in Kochia classification. Collecting more field data will be our focus to enhance the model's accuracy.

UAV-Based Multispectral Imagery for Mapping and Site-specific Management of Kochia Infestations. Thuan Ha*[1], Eric Johnson[2], Hema Duddu[1], Steve Shirtliffe[3], Steve Ryu[2]; [1]Dr., Saskatoon, SK, Canada, [2]Mr., Saskatoon, SK, Canada, [3]Prof., Saskatoon, SK, Canada (289)

A workflow was developed to explore the potential use of Quantix Recon UAV imagery for kochia mapping in cropland. Images with spatial resolution of 0.05 m in 4 spectral bands were collected in September 2021 over an area of nearly 1100 ha (15 fields) on four different crop types (lentil, pea, wheat, canola, and fallow) in the central region of Saskatchewan. Sampling data were collected from field and interpolated from the images. Accordingly, nearly 550 patches of kochia, crop, and bare soil were purposedly lineated. Along with Blue, Green, Red, and NIR, four more indices (including 2 new ones) were examined. A sample set of 4343 random points with 8 variables was divided into 70% - 30% for training and testing. Machine learning models of Random Forest (RF), Convolutional Neural Network (CNN), and Support Vector Machine (SVM) were applied in R software for image classification. Cross-validation was used for evaluating estimator performance. Preliminary results of the proposed workflow achieved an overall accuracy (and kappa) of 71% (0.58), 68% (0.55), and 70% (0.58) on RF, CNN, and SVM, respectively. It also revealed that a new proposed index named Modified Chlorophyl Index (mCI) is among top three variables of importance. Currently, our focus is on (1) on collecting more field data to enhance the models' accuracy, and (2) exploring the potential use of remote sensing data for kochia detection at broader spatial scales.

Germination and Growth Response of *Reynoutria x bohemica* to Red/far-red Light Applications. Delia D. Anderson*[1], David R. Clements[2]; [1]Trinity Western University, White Rock, BC, Canada, [2]Trinity Western University, Langley, BC, Canada (292)

Bohemian knotweed (*Reynoutria x bohemica*) is a growing problem in the Pacific Northwest, posing a risk to ecological and economic health in its invaded range. With a genetic combination of Giant and Japanese knotweed seeming to work synergistically, *R. bohemica* exhibits greater adaptability and invasion potential than either parent species. Although primarily reproducing vegetatively, seed production and germination rates in *R. bohemica* are high. Despite this, few seedlings are observed in situ. In this experiment red/far-red light regimes were used to test germination and seedling growth under a simulated canopy. It was hypothesized that lower R/FR light ratios would affect germination rates and morphology and physiology in seedlings. Seeds were collected from geographically separated populations in the Lower Mainland, BC and exposed to R/FR ratios of 0.3 (deep shade), 0.6 (partial shade), and 1.0 (full sunlight). The germination experiment revealed that seeds exposed to 0.3 R/FR had a germination success rate of 50%, while 0.6 and 1.0 both had a rate of 61%. Seedings germinated under normal conditions were exposed to the three R/FR light ratios for one month, then harvested for analysis. Data on above-ground height, chlorophyll, mass, and number of leaves was collected. RStudio (v. 1.4.1717) was used for statistical analyses. Height and mass variables showed a correlation (moderate, $p<0.05$) while mass also displayed correlation with leaf number (weak, $p<0.001$). Variables were analyzed using a two-way ANOVA. Mass and chlorophyll levels showed significant difference between R/FR ratios with $p<0.01$ for both. Height displayed significant difference between sites ($p<0.01$) but not R/FR applications. Leaf number did not significantly differ by site or R/FR ratio. These results suggest *R. bohemica* can germinate and grow under a dense canopy with a slight decrease in germination rate and small morphological and physiological impacts on seedling growth. Further studies would help to discern if *R. bohemica* could survive long-term under dense canopy conditions.

Recruitment Biology of Cleavers (*Gallium* Spp.) Populations in Western Canada. Dilshan Benaragama*; University of Saskatchewan, Saskatoon, SK, Canada (293)

Two types of cleavers (*Gallium aparine* and *Gallium spurium*) are known to inhabit many croplands in western Canada, and the latter is found to be the most dominant type. An increase in abundance of these species evading weed management either due to their wide ecological range or herbicide resistance development warrants a more comprehensive understanding of their developmental phenology. The objectives of this study were to understand the base temperature, emergence timing and plant morphological characteristics of cleavers and the potential variability across different populations. A thermal gradient plate experiment was conducted to determine the base temperature using five *G.spurium* populations and one *G.aparine* population collected from various Saskatchewan (SK) and Alberta (AB) locations. A common garden experiment of the above six populations was carried out to determine emergence characteristics and their morphological traits. The thermal gradient experiment determined that the base germination temperature was 2°C for all populations except for *G. aparine*, which was 4°C. Fifty percent of cleavers germinated by around 6 ºC -7 ºC. The field emergence study showed differences between populations with regard to the start of emergence (~150-250 GDD) and time to 50% emergence (~275-470 GDD) in spring. In fall, the start of emergence highly varied within a year due to population and among years (~200-600 GDD in 2013 and ~100-200 GDD in 2014), probably due to differences in moisture availability. Further, the emergence parameters (slope and time for 50% emergence) varied among populations and years. The fall emergence among populations was very low (1-9%) in comparison to spring emergence (2-17%). Despite differences in emergence timing, plant traits measured in the study did not differ among populations. This study provides some evidence that differences in emergence periodicity among populations can be a significant factor contributing to the success of this species as a weed even though it did not affect competitive traits.

Phenotypic Characterization of Watergrass (*Echinochloa* Spp.) in California Rice. Whitney Brim-DeForest*, Taiyu Guan, Troy Clark; University of California, Yuba City, CA (294)

A survey of watergrass (*Echinochloa* spp.) was conducted in August-September of 2020. Growers and Pest Control Advisors were contacted directly by University of California Cooperative Extension, and solicitations for additional locations were put out through social media and other communications. We also collected from our experimental fields in some cases, including UC Davis, the Rice Experiment Station, and grower collaborators. In total, we collected 64 samples, from across the rice-growing region. The greatest number of samples were collected from Sutter (36%) and Yuba (16%) Counties. In some fields, more than one sample was collected, if distinct biotypes of species could be distinguished visually from one another in the field. Each collected sample was used both for a phenotypic analysis as well as an herbicide screening. From the collected samples, we did a preliminary botanical analysis of the seeds, to determine if we had a representative sample of the watergrass species/biotypes in California. We used the following descriptions: new (unknown) biotype = small seeds, long awns; junglerice (*Echinochloa colona*) = extra small seeds, no awns; barnyardgrass (*Echinochloa crus-galli*) = small seeds, variable awns; late watergrass (*Echinochloa phyllopogon*) = large seeds, no awns. The vast majority of the samples were categorized as either barnyardgrass (48.4%, 31 samples) or the new (unknown) biotype (34.4%, 22 samples). In December 2020, the samples were first wet-chilled for two weeks to break dormancy, and then were planted in the UC Davis common greenhouse, in a Randomized Complete Block Design. Three plants of each sample were planted (three pots), and the entire set was replicated again in July 2021. Data collected included: days to heading, days to maturity, plant height, number of tillers, and length and width of flag leaf, as well as color of leaf sheath, leaf blade, internode, and node. Growth habit was recorded in the following categories: open, decumbent, and prostrate. Reproductive traits recorded included days to maturity of 50% of panicles, number of panicles, and panicle length. Seed characteristics included were hull color and awn length. The late watergrass (on average) headed 79.9 Days After Germination (DAG), the junglerice, barnyardgrass, and new (unknown) biotype headed on average at 68.5, 69.3, and 69.0 DAG, respectively. Awn length was longest for the new (unknown) biotype, with an average of 11.13 mm. Barnyardgrass had an average awn length of 7.66 mm, whereas junglerice was 4.40 mm, and late watergrass was 1.70 mm. Average height varied, with barnyardgrass the tallest at 162 cm, whereas the new (unknown) biotype was slightly shorter at 145 cm. Late watergrass was 119 cm on average, and junglerice was 136 cm on average (although it was prostrate). Number of tillers was greatest for late watergrass, at 14.9 tillers on average. Barnyardgrass, junglerice, and the new (unknown) biotype tillered significantly less, at 9.7, 11.3, and 8.9 tillers on average, respectively. Panicle weight did not vary significantly between the different species and/or biotypes. Average seed number (per panicle) varied, with late watergrass having the least seeds per panicle (124), the new (unknown) biotype at 171, junglerice with 173, and barnyardgrass with the most, at 215 seeds.

Investigating the Germination and Phenology Capabilities of *Parthenium hysterophorus* Populations in Israel. Sahar Malka*[1], Hanan Eizenberg[2], Maor Matzrafi[3]; [1]The Robert H. Smith Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Rehovot, Israel/Department of Plant Pathology and Weed Research, Agricultural Research Organization, Newe-Ya'ar Research Center, Ramat-Yishay, Israel, Rehovot, Israel, [2]Department of Plant Pathology and Weed Research, Agricultural Research Organization, Newe-Ya'ar Research Center, Ramat-Yishay, Israel, Ramat-yishay, Israel, [3]Department of Plant Pathology and Weed Research, Agricultural Research Organization, Newe-Ya'ar Research Center, Ramat-yishay, Israel (296)

Parthenium hysterophorus is a noxious weed species of the Asteraceae family that had invaded more than 50 countries worldwide. In Israel, *P. hysterophorus* was first documented in 1980 near a fishpond in Tirat Zvi, located in eastern-northern Israel. In recent years, there has been an increasing concern about the spread of this noxious weed in agricultural and non-agricultural habitats, along with the identification of several populations in southern areas to the spread origin. Our work is aimed to study germination under changing environmental conditions among different populations of *P. hysterophorus*. We examined seeds that were collected form five locations across Israel, Dgania Beit, Tirat Zvi, Hahotrim, Amikam and Newe Ya'ar. Locations vary in climatic and environmental conditions. Seed weight was recorded alongside other spatial seed parameters that were estimated using electronic microscope (Hitachi TM 3000). Seed germination was documented for each population under dark conditions at several constant temperatures (10, 15, 20, 25, 30 and 35°C) and water potentials (0, -0.2, -0.4, -0.6, -0.8 and -1 MPa at 20°C). Thirty-two plants of each population were grown in a greenhouse under controlled environmental conditions, several life cycle traits such as emergence, bolting and flowering were recorded for each plant. No significant differences were recorded for seed weight and seed spatial parameters among *P. hysterophorus* populations. For germination studies, we observed different germination capabilities among populations, seeds of Tirat Zvi and Amikam presented with higher germination rate over a wide range of temperatures. However, for seeds of all populations, optimal germination was recorded at ~20°C. Germination was recorded for all water potentials excluding -1MPa, while for -0.8 and -0.6 MPa low germination rates were recorded for seeds of all populations. However, seeds of the Amikam population presented the highest germination capabilities under negative water potentials. Differences in phenological characteristics were observed between the different populations, Tirat Zvi bolted first while Hahotrim bolted last. It was noticeable that the growing rate of the plants (rosette diameter, plant height) was different between populations, although plants final weight did not show a significant difference. Understanding the variation of the biology and phenology among different populations of *P. hysterophorus* may serve as a key factor in creating new and integrated weed management approaches for the control of this noxious weed species.

Oral 10. Physiology

Genome-wide Evolutionary Analysis of Putative NTSR Genes in Monocots and Dicots.
Saket G. Chandra, Ramon G. Leon*; North Carolina State University, Raleigh, NC (301)

The widespread use of herbicides and their repeated use with limited diversity of mechanisms of action has favored the evolution of herbicide resistance in weedy plants. Target-site has been the most commonly reported and studied type of resistance, but there is concern that non-target-site resistance (NTSR) will become more prevalent making weed management more difficult. The genetic basis of NTSR are widely unknown, so in this study four major gene groups encoding putative NTSR enzymes, namely, Cytochrome-P450, Glutathione-S-transferase, Glycosyl transferase and Nitronate monooxygenase were analyzed in different monocot and dicot species including several weed species with confirmed herbicide resistance. Phylogenetic analysis revealed that all four NTSR proteins of monocot and dicot sequences are split into different clades and monocots further subdivided into different subclades. Promoter sequences of these NTSR genes contained six stress related cis-regulatory motifs and nine transcription factor binding sites. Additionally, the identified motifs indicated that NTSR proteins are conserved among higher plants, indicating that the motifs are important for NTSR protein function. Overall, our findings are a significant step toward a better grasp of metabolism-based herbicide resistance, which may be used to develop innovative weed control techniques.

Palmer Amaranth (*Amaranthus palmeri*) Resistance to Glufosinate. Matheus Machado Noguera*[1], Aimone Porri[2], Isabel Schlegel Werle[1], James W. Heiser[3], Taghi Bararpour[4], Steven Bowe[5], Nilda Roma-Burgos[1]; [1]University of Arkansas, Fayetteville, AR, [2]BASF SE, Limburgerhof, Germany, [3]University of Missouri, Portageville, MO, [4]Mississippi State University, Stoneville, MS, [5]BASF Corporation, Research Triangle Park, NC (305)

In a large-scale screening involving Palmer amaranth populations collected in 2020 from Missouri and Mississippi, several accessions had survivors when sprayed with a full rate of glufosinate (655 g ai ha^{-1}, Liberty 280 SL). F1 populations were produced by growing survivors from the same field population together. Dose response assay was performed on putative resistant accessions and their progenies. A population from Missouri, hereafter called MO#2, showed 3.5-fold increase in ED50, while its progeny was 7.2 times more resistant than the sensitive population. Four glutamine synthetase (the target site of glufosinate) isoforms were identified from the Palmer amaranth genome sequence data. Only three of these isoforms were expressed: one expressed in the plastid (commonly referred to as GS2) and two that are localized in the cytoplasm (commonly referred to as GS1; hereafter called GS1.1 and GS 1.2). Sequence analysis of these three isoforms in 15 glufosinate survivors did not reveal mutations associated with resistance. GS2 with mutations at the residues involved in substrate binding were expressed in *E. coli*, and protein activity was assessed. None of the 17 mutants tested produced an active enzyme, which suggests that resistance-conferring SNPs at those loci are unlikely. Glufosinate was also sprayed in association with metabolic inhibitors (P450s and/or GSTs) on both field and F1 populations, but the resistance was not reversed. Finally, the copy number and expression of the three GS isoforms were determined. The 12 glufosinate survivors studied harbored up to 30 copies of GS2 whereas susceptible plants had a single copy GS2 was expressed up to 42-fold among glufosinate survivors. GS1.1 was also overexpressed, although not more than 5-fold. GS1.2 was found as a single copy only. Ammonia accumulation assay was conducted on the same 12 resistant (R) plants and 12 plants from a sensitive (S) population. R plants accumulated less ammonia than S plants, but ammonia level was not correlated with GS fold-change, indicating that, although overexpression of GS isoforms is the major mechanism of resistance to glufosinate in Palmer amaranth, additional mechanisms are involved.

Kochia and Russian Thistle IWGC Genome Sequencing and Impact. Philip Westra*[1], Jacob S. Montgomery[1], Todd A. Gaines[1], Eric L. Patterson[2], Sarah Morran[1]; [1]Colorado State University, Fort Collins, CO, [2]Michigan State University, East Lansing, MI (306)

Kochia and Russian thistle IWGC genome sequencing and impact.

Oral 12. Integrated Weed Management

A Review of Selected Published Herbicide Resistance Validations. Harry J. Strek*[1], Mark Peterson[2], Ian M. Heap[3]; [1]Bayer AG, Frankfurt Am Main, Germany, [2]Dow AgroSciences LLC, West Lafayette, IN, [3]WeedScience LLC, Corvallis, OR (307)

A review of 80 publications published between 2009 to 2020 was conducted to ascertain whether they followed the Global HRAC (Herbicide Resistance Action Committee) guidelines for validation of herbicide resistance. They were chosen using a title keyword search that identified 3840 potential candidate publications, which were distilled down to 340 for a detailed review that eventually led to the 80 chosen to be critically reviewed. They represented 22 countries where the studies were conducted, with three countries, USA, Brazil and China representing 50% of the reviewed publications, and were published in 30 journals, with five, Pest Management Science, Pesticide Biochemistry and Physiology, Planta Daninha (renamed Advancements in Weed Science), Weed Science, and Weed Technology, representing 58%. A large majority of the publications (88%) followed the HRAC guidelines, used accepted procedures for the validation (86%) with herbicides applied within the label specifications (89%), had demonstrated the heritability of resistance (95%) and that natural selection had taken place (88%), as far as could be ascertained. However, only 55% had demonstrated the practical field impact of the labeled rate, while only 35% confirmed that the weeds were identified to species level. Just 33% provided information on field history, at least for herbicide use. Most (91%) used the required minimum number of doses or more for the dose-response curve (3), and followed most other recommended procedures, including the use of adequate and relevant control populations (89%). Details of the validation procedures are presented and discussed.

Integration of Precision Agriculture Technology for Weed Control in Semiarid U.S. Great Plains: Opportunities and Challenges. Priyanka Sharma*[1], Vipan Kumar[2]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS (308)

The no-tillage (NT) dryland crop production in the central Great Plains (CGP) has historically relied on chemical-based weed control. However, the frequent use of herbicides with the same site of action (SOA), and lack of diversity in weed control practices resulted in widespread evolution of herbicide resistance in dominant weed species in the region. Lack of cost-effective strategies and alternative new herbicide SOA further complicate the management of herbicide-resistant (HR) weeds. Increasing herbicide costs, dwindling herbicide resources, lower commodity prices, consolidation of small farms to large farming operations, and improvement in technologies (such as advancement in sensors/cameras, data collection, storage, and analysis) over the last two decades has recently spurred interests among weed researchers and producers to incorporate precision agricultural (PA) technologies for weed control. Integration of PA technologies potentially offers several benefits, including but not limited to field mapping of problematic (HR and non HR) weed populations (via remote sensing or unmanned aerial vehicles such as drones equipped with cameras/sensors), site-specific weed control or spot treatments (various technologies such as see and spray, green on brown or green on green, and various spray drones and spray aircrafts), reduction in pest management inputs, and overall improvement in environment and human health. This paper aims to highlight the role of PA tools as an important component of integrated weed management (IWM), with emphasis on exploring emerging PA technologies; their potential use, economic viability, agronomic benefits, and constraints preventing adoption of PA techniques in the CGP region. We will also highlight current knowledge gaps and propose new research priorities for integrating PA technologies in this water-limited environment.

Advances in Precision Weed Management, 2022. Vijay Singh*[1], Dhiraj Srivastava[1], Vipin Kumar[1], William Reynolds[2], Daniel E. Martin[3]; [1]Virginia Tech, Painter, VA, [2]LeadingEdge Aerial Technologies, Smyrna Beach, FL, [3]USDA- ARS, College Station, TX (309)

In Agriculture, Unmanned Aerial Systems are potentially used to map vegetation, irrigation, and characterize pests in a crop field utilizing onboard sensors. Integration of Unmanned Aerial System (UAS), GPS technology, and Machine Learning models have made it possible to manage weeds through site-specific weed management operations. Machine Learning-assisted weed identification and classification require weed signature database and modeling approach with high precision. One of the major challenges in training classification models is the lack of weed image database and difficulty in collecting sufficient number of images for this purpose. This problem can be solved by using Data Augmentation techniques. Studies were conducted at Eastern Shore AREC, Virginia Tech, Painter, VA, in 2020-2021, for collecting image data with implementation of data augmentation approaches to create digital weed signature libraries of Italian ryegrass, and common ragweed. For Italian ryegrass, Bayesian optimization was used to select best hyperparameter values for model and model reached the 98% validation accuracy in just 10 iterations. Our model achieved the recall of 97.5% and precision of 100% for detecting the Italian ryegrass in wheat. Similarly, our model for common ragweed outperformed the state-of art BiT model in classification within a soybean field and achieved test accuracy >85%, with precision >80% and recall >90%. We conducted UAS-based broadcast- and spot-spray herbicide applications to evaluate the technology, herbicide efficacy, and economics. Broadcast applications in corn, cotton, soybean, and wheat were conducted with UAS at 18.7 L ha^{-1}, and 37.4 L ha^{-1} and compared with backpack spray applications (140 L ha^{-1}). The UAS-based applications with Liberty herbicide indicated 90-95% weed control which was similar to the control with backpack sprayer at early-POST stage. For site-specific management, 20 spots were chosen at random, field was mapped with DJI M300, and geocoordinate information (ESRI shape file) was used for automatic spray applications with Precision Vision 35X. Results have indicated that this technology can perform semi-automatic spray operations with a frequency of 65% hitting target within 25-cm of radius. Overall weed control efficacy of spot spray was 94%.

Regional Differences in Cover Crop Performance and Herbicide Efficacy Affect Integrated Weed Management in Soybean. Eugene P. Law*[1], Steven Brian Mirsky[2], Mark VanGessel[3], Victoria Ackroyd[4], Muthukumar V. Bagavathiannan[5], Kevin W. Bradley[6], William S. Curran[7], Adam S. Davis[8], Jeffrey Evans[9], Wesley Everman[10], Michael L. Flessner[11], Nicholas R. Jordan[12], Lauren M. Lazaro[13], Ramon G. Leon[10], John Lindquist[14], Jason K. Norsworthy[15], Lovreet S. Shergill[16]; [1]University of Delaware, Beltsville, MD, [2]USDA- ARS, Beltsville, MD, [3]University of Delaware, Georgetown, DE, [4]University of Maryland, College Park, MD, [5]Texas A&M University, College Station, TX, [6]University of Missouri, Columbia, MO, [7]Penn State University, Bozeman, MT, [8]University of Illinois, Urbana, IL, [9]Farmscape Analytics, Concord, NH, [10]North Carolina State University, Raleigh, NC, [11]Virginia Tech, Blacksburg, VA, [12]University of Minnesota, St. Paul, MN, [13]Louisiana State University, Baton Rouge, LA, [14]University of Nebraska-Lincoln, Lincoln, NE, [15]University of Arkansas, Fayetteville, AR, [16]Montana State University, Huntley, MT (310)

Soybean production is threatened by the increasing prevalence of multiple-herbicide resistant (MHR) weeds that leave few options for chemical management. Integrated weed management (IWM) strategies that combine chemical and non-chemical control tactics can slow or prevent MHR development by reducing reliance on herbicides. In this study we assessed the impact of integrating cereal rye cover crops with standard herbicide programs for IWM in soybean. A common experiment was conducted at 11 sites in the Getting Rid Of Weeds research network over four years, examining the interaction of cover crop termination timing and herbicide program on cover crop biomass, weed emergence and biomass, and soybean yield. Delaying cover crop termination to two weeks before soybean planting increased cover crop biomass, decreased weed biomass, and had no effect on soybean yield in most site years. Standard herbicide programs (i.e., typical management for a given site) provided good weed control in most site years, but including cover crops improved control in site years where herbicides were less effective. Regional differences in environmental conditions and weed populations likely influenced the performance of cover crops and herbicide programs. The effects of cover crop termination timing on weed seedling emergence will also be discussed.

Long-Term Effects of Tillage and Cover Crops on the Weed Community. Mackenzie R. Trader*[1], Karl W. J. Williard[1], Jon E. Schoonover[1], Randy McElroy[2], Amir Sadeghpour[1], Karla L. Gage[1]; [1]Southern Illinois University, Carbondale, IL, [2]Bayer Crop Science, Farina, IL (311)

One of the major challenges farmers face every growing season is weed control. With herbicide efficacy declining as weeds continue to evolve and resist key modes of action, long-term, multi-faceted control practices need to be investigated. A long-term field study was established in 2013, to examine changes and differences in distribution and composition between individual species in the weed community in response to cover crop rotations and tillage. A split-plot design with three crop rotation systems was implemented: 1) corn (*Zea Mays* L.) – cereal rye (*Secale cereale* L.) – soybean (*Glycine max*) – hairy vetch (*Vicia villosa* R.) [CcrShv], 2) corn-cereal rye-soybean-oats + radish (*Avena sativa* L. + *Raphanus sativus* L.) [CcrSor], and 3) corn-no cover crop-soybean-no cover crop [CncSnc], and two tillage treatments: conventional tillage and no-till. The seeding rates for cereal rye, hairy vetch, and oats + radish were 87, 28, and 39 kg ha^{-1}, respectively. To assess the weed community present in the seedbank, two soil cores with a volume of 120 cm^3 (r=2.26 cm; h=7.5 cm) were taken per sub-plot in the spring of 2016, fall of 2016, and fall of 2019. A soil grow out was conducted in the greenhouse where emerged weeds were counted, identified, then removed from the sample. To examine the above ground weed community before cover crop termination in the spring of 2021, percent coverage was collected for each weed species, cover crop, crop residue, and bare ground, in two 0.5m^2 areas in each subplot, then averaged. Permutational Multivariate Analysis of Variance (PERMANOVA) suggested a significant difference between tillage systems on the weed seed bank community for all three time periods. PERMANOVA also suggested a significant difference between cover crops for the percent coverage of the above ground weed community, but there was no interactive effect of tillage. A Repeated Measures PERMANOVA analysis suggested an interactive effect of tillage and the three sample collection timings on the weed seedbank. 3-Way ANOVAs suggested time, tillage, and crop rotation influenced each weed species differently. These data suggest that a weed management plan with diverse methods of control may alter the weed community over time.

The Impact of Hog Grazing Vs. Conventional Tillage on Weed Presence in Subsequent Vegetable Crops. Leah Sandler*, Micheal Robinson, Kent Mullinix; Institute for Sustainable Food Systems, Vancouver, BC, Canada (312)

Contemporary global-industrial agriculture has gravitated toward increasing specialization; resulting, generally, in the loss of integrated crop and livestock systems. It is well-documented that specialization of farming systems can lead to environmental harm, the overconsumption of natural resources, nitrate pollution, and degradation of soils from over-reliance on mechanical tillage. Integrated Crop-livestock Systems (ICLS) systems have multiple enterprises and functions that interact in space and time and benefit from synergistic resource transfers. ICLS may represent a model of sustainable farming according to agroecological principles of nutrient recycling, increase efficient use of land and resources and have the potential to be widely adopted by small-scale farmers. Despite heightened interest and the benefits of livestock integration, the complexity of such systems and the lack of research constrain adoption. Research was conducted from 2019-2021 in Tsawwassen, BC involving the integration of hogs and cover crops with vegetable production to determine the viability, applicability and scalability of the system. Results sought to investigate the impacts of integrating hog strip grazing in a market vegetable – cover crop rotation system on weed management and yield in subsequent vegetable crops. There were significantly more weeds in the 2020 crop season (1,650 per acre compared to 1,000 per acre in 2021), but no statistical differences in weed presence between treatments. In 2020, sweet corn yields were larger in the grazed treatments (57,040 kg $acre^{-1}$) than conventional tillage treatments (30,160 kg $acre^{-1}$). Yields were considerably lower, for both treatments in 2021 due to periods of extreme heat and drought throughout the season. Corn yield for grazed and conventionally tilled plots were 26,280 and 25, 840 kg $acre^{-1}$, respectively. More long-term research is needed to determine the impact of hog grazing on depleting the weed seed bank and rooting perennial weed species.

Evaluating the Potential of Chaff Lining in Winter Wheat and Soybean Production.
Matthew P. Spoth*[1], Michael L. Flessner[1], Travis Legleiter[2], Lauren M. Lazaro[3], Kevin W. Bamber[1], Wykle C. Greene[1], Eli C. Russell[1], Cynthia Sias[1], Vipin Kumar[4], Vijay Singh[4]; [1]Virginia Tech, Blacksburg, VA, [2]University of Kentucky, Princeton, KY, [3]Louisiana State University, Baton Rouge, LA, [4]Virginia Tech, Painter, VA (313)

Chaff lining is a form of harvest weed seed control in which the chaff fraction of harvest residues and weed seed therein are concentrated into a narrow line behind the combine. The objectives of this study were to determine how varying wheat and soybean yields will affect chaff lining control of select weed species and examine subsequent crop performance. Weed species of interest included Palmer amaranth (PA) (Amaranthus palmeri S.) and common ragweed (CR) (Ambrosia artemisiifolia L.) subject to soybean chaff lining and wild mustard (Sinapis arvensis L.) and Italian ryegrass (Lolium perenne L. ssp. multiflorum (Lam.) Husnot) in wheat chaff lining, with each evaluated in separate experiments. Chaff lines were created to mimic a range of wheat and soybean yields with equal weed seed additions to each chaff line, based on previous weed seed rain studies. A conventional harvest or control treatment and an outside-the-chaff-line treatment were included, where total fecundity or weed seed rain occurring prior to harvest were broadcast respectively. Our wheat chaff lining results indicate there was a reduction in subsequent crops' (double crop soybean and wheat) emergence through chaff lines compared to conventional harvest. However, by crop harvest no differences were observed in double crop soybean yield across treatments on a field scale, which accounts for both chaff lines and areas outside the chaff line. Likewise, no differences were observed in wheat yield besides one location where conventional harvest resulted in 27-29% less yield than chaff lining. Soybean chaff lining reduced subsequent drilled cereal rye cover crop emergence in all chaff lining treatments at two of four locations, yet no differences in full season soybean yield or cover crop above ground biomass were observed. Total weed emergence over the growing season was reduced by 33-48% at a field scale in soybean and 57-68% in wheat chaff lining, indicating chaff may alter the environment to be unfavorable for weed seed emergence. These initial results are very promising and indicate potential for chaff lining to improve weed management and combat herbicide resistance.

Palmer Amaranth Suppression in Soybean as a Result of Cover Crop Termination Timing and Method. Cynthia Sias*, Michael L. Flessner, Kevin W. Bamber, Eli C. Russell, Wykle C. Greene, Matthew P. Spoth, Sara Peters; Virginia Tech, Blacksburg, VA (314)

There is a growing need for non-chemical weed control options due to the growing issue of herbicide-resistant weed species such as Palmer amaranth (*Amaranthus palmeri* L.). Growing interest in the use of cover crops (CC) has led to questions regarding the most appropriate forms of CC termination prior to cash crop planting in order to maximize weed suppression benefits. Experiments at two locations were conducted in 2021 to test the factors of 1) cereal rye CC termination timing (i.e. planted "green" or "brown"), 2) CC biomass (i.e. none, low, medium, or high), and 3) CC termination method (i.e. rolled vs. standing) on Palmer amaranth suppression. Each experiment was a randomized complete block design with four replications per treatment. Cover crop biomass was measured at soybean planting. Palmer amaranth emergence counts were evaluated at 4 and 6 weeks after soybean planting, and soybean yield was calculated at harvest. To explore the ideal combination of termination tactics to maximize weed suppression, all of the data were analyzed using ANOVA in JMP Pro 16. At 4 weeks after soybean planting, as CC biomass increased Palmer amaranth density decreased at one location, but a trend was not observed at the other location. Standing CC was more successful at suppressing Palmer amaranth when compared to the rolled CC treatments at one of two locations. At 6 weeks after soybean planting , the high biomass plots displayed reduced Palmer amaranth density when compared to the low CC biomass plots at both locations. These results support previous research indicating that growers should maximize CC biomass to maximize weed suppression, as well as research that suggest a standing cover crop may be more effective at reducing weed emergence. Future research is ongoing and this experiment will be repeated to further confirm observations.

Growing Point Detection in Weeds for Greater Robustness Against Occlusion in Digital Image Analysis. Daniel J. Ginn*[1], Chris Reberg-Horton[2], Steven Brian Mirsky[3], Muthukumar V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]North Carolina State University, Raleigh, NC, [3]USDA- ARS, Beltsville, MD (317)

Precision weeding robots increasingly have a place on the modern farm, but they rely on our ability to effectively detect weeds using machine vision. The existing weed detection algorithms are limited to detecting solitary weeds, and do not perform well under situations of occlusion. The objective of this research was to evaluate two methods of weed detection under increasing levels of occlusion, by generating synthetic datasets with occlusion levels ranging at 10% increments from 0 – 50%. This was first done using a fully synthetic dataset of sugarbeet with the weeds namely *Galium aparine* and *Capsella bursa-pastoris*, and followed up with a semi-synthetic dataset of cotton with *Amaranthus palmeri* and monocot weeds. The two different weed detection approaches compared under increasing levels of occlusion was growing-point detection and semantic segmentation. Finally, to assess effectiveness a simulation of weed control was run using the predictions of the neural networks. For the growing point detection architectures a 1cm radius area was considered destroyed by some tool such as mechanical stamping, laser or electrocution. If this destroyed area had a greater than 50% IoU with a 1cm radius circle centered at the true growing point of the plant, that plant was considered destroyed. For the semantic segmentation architectures, a 1cm resolution grid was overlaid on the image, representing the minimum resolution of a precision micro-dose spray system. If a cell was more than 4% weed pixels the whole cell was sprayed, with all pixels in the cell considered destroyed. The metrics used for reporting are Precision and Recall, with Precision reporting how much damage was done to the crop, and Recall reporting what percentage of the weeds were successfully targeted. The hypothetical weeding approach was chosen to produce more applicable and realistic results in the case of precision weeding robots, instead of reporting accuracies that would make no difference for weed control. The Neural Network architectures used were a custom Encoder-Decoder design modelled on UNet and Mask RCNN for growing point detection, and Mask RCNN and Deep Lab V3+ for semantic segmentation. The results found in this study, after application of hypothetical weed control, showed that growing point detection achieved a very high Precision of 0.987 and 0.997 at the maximum 50% occlusion tested, indicating almost no inadvertent crop damage even under high levels of occlusion. Mask RCNN for semantic segmentation reported a stable 0.96-0.94 Precision once occlusion began to occur, indicating a fixed level of damage to crops over increasing levels of occlusion. Deep Lab V3+ performed particularly poorly at levels of occlusion higher than 20%, falling from 0.957 to 0.511 at 50% occlusion. For Recall, which reports the percentage of missed weeds, a roughly concave down parabolic decay rate over the occlusion levels was reported for all but one of the architectures starting at ~0.99 and ending around 0.9. The exception was Mask-RCNN for semantic segmentation which had a concave up parabolic decay starting at 0.97 and ending at 0.90. These decay rates imply that the growing point detection methods miss less weeds over the 0-50% occlusion range than the Mask-RCNN segmentation method. This research quantified the effect of increasing levels of occlusion on two major weed detection methods, with growing point detection proving to be more robust than semantic segmentation.

Automated High-throughput Herbicide Resistance Diagnostics - Benefits and Limitations.
Anita Küpper*, Veronika Brabetz, Falco Peter, Thomas Schubel, Simon Schepp, Julia Unger; Bayer AG, Frankfurt, Germany (319)

The steady increase of herbicide resistance cases in weeds worldwide has also led to an increase in the demand for herbicide resistance testing. Especially laboratory diagnostic methods provide robust information about resistance mechanism and status within a field with a fast turnaround time from sampling to analysis. This talk will describe how Bayer performs diagnostic testing for different resistance mechanisms and how the results help to provide farmers with in-season herbicide application recommendations to support best weed management practices. Furthermore, it highlights the benefits and limitations of high-throughput resistance diagnostics. Regardless of the continued technological advances that are made in this field, the steady increase in species that become resistant, the continued spread of resistance, the increase of resistance to different sites of action and the increase of different resistance mechanisms require to focus diagnostic efforts to balance costs and benefits.

A Closer Look at the Spatial Distribution and Temporal Dynamics of Weeds Within Fields.
Lior Blank*[1], Roni Gafni[2], Gal Rozenberg[3]; [1]Agricultural Research Organization, Volcani Center, Rishon Lezion, Israel, [2]HUJI, Ramat Yishay, Israel, [3]Technion-Israel Institute of Technology, Haifa, Israel (320)

Compared to the relatively well-studied spatial aspects of weeds in agricultural fields, temporal aspects, which require data collection in subsequent years, have got little attention. Understanding weeds' spatio-temporal dynamics is important as the spatial distribution of weeds from one year could serve as a basis for making management decisions in the following year. Based on a literature review we conducted recently, 64% of studies, focusing on the spatio-temporal distribution of weeds, lasted only 1-2 years with most fields sampled once within a season, not enough time to study temporal dynamics of weed distribution. Despite the general tendency for species to aggregate, we found that a few species had contrasting spatial patterns between studies, highlighting the need to better understand the conditions affecting weed spatio-temporal dynamics. We report the findings from two studies. In a study of 11 commercial dry onion (*Allium cepa* L.) fields, we found that weed communities tended to cluster. Weeds covered less than 7% of the field in five of the fields, whereas herbicides were applied uniformly over the entire field, demonstrating the potential in reducing herbicides use by accounting for the actual distribution of weeds. In another study, we examined the temporal stability of *Ecballium elaterium* patches in four commercial almond orchards, and found that the location of these patches remained constant throughout the three-year study period. This makes *E. elaterium* a suitable target for site-specific weed management and for pre-emergence patch spraying, when no visual information is available in the field. To maintain high yields, herbicides are essential, but their use should be optimized. Weed management can be improved by understanding the spatial interactions and feedbacks between weeds and their environment at the field scale.

Inter-seeding Winter Wheat in Soybeans for Early-Season Weed Suppression. Madison R. Decker[1], Karla L. Gage*[2], Ronald F. Krausz[2]; [1]Southern Illinois University, Washington, IN, [2]Southern Illinois University, Carbondale, IL (322)

There is documented common waterhemp resistance to seven herbicide site of action groups in Illinois and three in Indiana. Due to the selection of herbicide-resistant weed biotypes, there is an urgent need to progress towards more sustainable weed management practices that increase biodiversity, crop productivity, and reduce reliance on chemical weed control. Therefore, field studies were conducted in 2019, 2020, and 2021 at the Southern Illinois University Agronomy Research Center (ARC) in Carbondale, Illinois and at the Belleville Research Center (BRC) in Belleville, Illinois as well as on farms across Illinois and Indiana to determine the effect of inter-seeding winter wheat in soybean on *Amaranthus* species (common waterhemp and Palmer amaranth) suppression and soybean development. Winter wheat termination date and its impact on soybean development in a weed-free study was evaluated at the BRC site. Winter wheat was planted concurrent with soybean and the inter-seeded winter wheat was terminated at various soybean growth stages from soybean vegetative stage V2 until V6. Winter wheat planting date and herbicide programs for the control of common waterhemp were evaluated at the ARC and BRC site. Winter wheat was planted on four different dates: prior to soybean planting in April, early May, or at soybean planting in late May. October planted winter wheat was terminated in April. Results from the 2019 termination date study indicated no significant differences in yield among inter-seeded treatments where winter wheat was terminated by V3 or in 2020 by V6 when compared to the standard soybean-only preemergence (PRE) followed by (fb) post-emergence (POST) program. In the 2020 planting date study, at both locations, 0 days after the POST, common waterhemp biomass was significantly reduced when compared to the soybean-only non-treated treatment when winter wheat was planted prior to soybean at the fall, April, and early May planting dates. Yield from the 2020 ARC planting date study indicated that planting winter wheat concurrent with soybean resulted in no yield reduction compared to the standard soybean-only plots. In the 2020 BRC planting date study, inter-seeding winter wheat at any of the planting dates with a PRE fb POST program yielded the same as the standard soybean-only PRE fb POST program. On-farm trials were implemented in three locations: Red Bud, Illinois, Salem, Illinois, and Washington, Indiana to investigate this integrated weed management program on a larger scale. Results from this 2021 research indicate that there was no significant difference between the number of emerged *Amaranthus* species in the winter wheat inter-seeded in soybean and the soybean-only PRE fb POST treatment 0 days after POST (DAP). Additionally, the use of winter wheat inter-seeded in soybean reduced the height of *Amaranthus* species 0 DAP when compared to the soybean-only PRE fb POST and the soybean-only POST only treatments. 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 *Amaranthus* species.

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