DOES GLYPHOSATE INFLUENCE MANAGEMENT OF RHIZOCTONIA CROWN AND ROOT ROT IN GLYPHOSATE-RESISTANT SUGARBEET? Kelly A. Barnett, Christy L. Sprague, William W. Kirk, and Linda E. Hanson, Graduate Student, Associate Professor, Department of Crop and Soil Sciences, Associate Professor, Department of Plant Pathology, Michigan State University, Adjunct Assistant Professor, USDA-ARS and Department of Plant Pathology, East Lansing, MI 48824.

Previous greenhouse research with glyphosate-resistant sugarbeet has indicated that host plant resistance to Rhizoctonia crown and root rot could be compromised in certain varieties when plants were exposed to glyphosate. In order to improve disease management recommendations, field research was conducted in 2008 and 2009 to: 1) examine the response of glyphosate-resistant sugarbeet varieties to the interaction of herbicide treatment and *Rhizoctonia solani*, and 2) examine the interaction of weed and disease management strategies on Rhizoctonia crown and root rot in four glyphosate-resistant sugarbeet varieties. The four glyphosate-resistant sugarbeet varieties examined were ACH 827RR, Hilleshog 9027, Hilleshog 9028, and Hilleshog 9029. Each of these varieties were treated with three different herbicide programs: 1) no herbicide, 2) a standard-split herbicide program (two applications of desmedipham & phenmedipham + triflusulfuron + clopyralid + non-ionic surfactant), and 3) three applications of glyphosate + ammonium sulfate. Non-inoculated and plots inoculated with *Rhizoctonia solani* AG-2-2 IIIB at 6-leaf sugarbeet were compared for each variety by herbicide program combination. Additional treatments included inoculated plots treated with the fungicide azoxystrobin in-furrow or postemergence to 6-leaf sugarbeets combined with the three herbicide programs. The experiment was arranged as two split-split plot designs to address the two objectives and plots were replicated four times. For the first objective, Rhizoctonia inoculation was the main plot factor, sugarbeet variety was the sub-plot factor, and herbicide program was the sub-sub plot factor. For the second objective, sugarbeet variety was the main plot factor, herbicide program was the sub-plot factor and fungicide treatment was the sub-sub plot factor. Ten weeks after Rhizoctonia inoculation sugarbeet roots were harvested and each root was evaluated for disease severity on a scale from 0 to 7, with 0 = healthy and 7 = dead sugarbeets. Disease severity ratings of 1 or less are considered healthy sugarbeets and ratings of 3 or less are considered harvestable. Inoculation was a significant factor for Rhizoctonia disease severity. Plots that were not inoculated with Rhizoctonia had a disease severity rating of less than 1 and were not included in further statistical analysis. Herbicides and interactions with herbicide programs were not significant. However, sugarbeet variety was significant for disease severity and harvestable sugarbeets. ACH 827RR was the most susceptible to Rhizoctonia crown and root rot and only 36% of the sugarbeets were considered harvestable. The other three varieties had similar disease severity ratings (3.5 to 3.9) and Hilleshog 9027 and Hilleshog 9029 had the highest percentage of sugarbeets that were considered harvestable (>55%). In 2008, there was a significant variety by fungicide interaction. Foliar applications of azoxystrobin provided the greatest protection from Rhizoctonia crown and root rot. The sugarbeet varieties Hilleshog 9027 and Hilleshog 9029 combined with in-furrow applications of azoxystrobin provided similar Rhizoctonia suppression as the foliar azoxystrobin applications to three of the four sugarbeet varieties. In 2009, there was not an interaction between variety and fungicide and the main effects variety and fungicide treatment were significant for disease severity. All three Hilleshog varieties were more tolerant to Rhizoctonia compared with ACH 827RR and foliar applications of azoxystrobin provided the greatest suppression of Rhizoctonia crown and root rot. Results indicate that weed management strategy had little impact on Rhizoctonia crown and root rot. However, a combination of planting a Rhizoctonia-tolerant variety and foliar azoxystrobin applications were the best options for managing Rhizoctonia crown and root rot.

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RESPONSE OF DRY BEAN TO PREEMERGENCE AND POSTEMERGENCE APPLICATIONS OF CLORANSULAM-METHYL. Nader Soltani, Christy Shropshire and Peter H. Sikkema. Department of Plant Agriculture, University of Guelph Ridgetown Campus, Ridgetown, ON N0P 2C0.

Tolerance of various market classes of dry bean to cloransulam-methyl is not known. Three field studies were conducted in Ontario during 2007 and 2008 to determine tolerance of black, cranberry, kidney and white bean to the pre-emergence (PRE) and post-emergence (POST) application of cloransulam-methyl applied at 17.5, 35, and 70 g ai ha^{-1}. Cloransulam-methyl applied at 17.5, 35, and 70 g ha^{-1} caused between 4 and 23% injury in black, cranberry, kidney, and white bean. Cloransulam-methyl applied at 17.5, 35, and 70 g ha^{-1} reduced shoot dry weight between 16 and 28% compared to the non-treated control. Cloransulam-methyl applied PRE reduced black bean height 27% and cranberry bean height 25% at 70 g ha^{-1} and reduced white bean height 19% at 35 g ha^{-1} and 37 % at 70 g ha^{-1}. Cloransulam-methyl applied PRE reduced the yield of black bean 29% at 35 g ha^{-1} and 43% at 70 g ha^{-1}, cranberry bean 43% at 70 g ha^{-1} and white bean 36% at 35 g ha^{-1} and 54% at 70 g ha^{-1}. Based on these results, there is not an adequate margin of crop safety for the PRE and POST application of cloransulam-methyl in black, cranberry, kidney and white bean at the rates evaluated.

IMPACT OF TILLAGE SYSTEM AND APPLICATION TIMING OF POSTEMERGENCE HERBICIDES ON ITALIAN RYEGRASS CONTROL. James R. Martin, Charles R. Tutt, and Dorothy L. Call, Extension Professor, Research Specialist, and Technician, Department of Plant and Soil Sciences, University of Kentucky, Princeton, KY 42445-0469.

Because of the increased interest in using no-tillage practices in wheat, research was conducted to determine if tillage system impacts Italian ryegrass growth and control when a postemergence herbicide is applied in the fall or spring. Experiments were conducted during 2006-2007, 2007-2008, and 2008-2009 growing seasons and were referenced as studies 1, 2, and 3 respectively.

Wheat was planted using conventional and no-tillage practices in mid October. The timings of applications common to all three studies were mid November and mid March. Studies 2 and 3 also included a mid December timing.

Mesosulfuron methyl was used in the first two studies for managing ryegrass. Crop injury became a concern when mesosulfuron methyl was applied in the spring near the time for topdressing nitrogen fertilizer; therefore, pinoxaden was used in the third study for postemergence control of ryegrass.

Ryegrass plant samples were collected at the time of application to estimate density and growth stage. Visual ratings of control were also made at 4 weeks after treatment (WAT) and at maturity. Wheat was harvested with a plot combine and yields were adjusted to 13.5 percent moisture.

Tillage system influenced ryegrass density in two of the three studies, yet results were inconsistent. Densities in the first study were greater in the conventional tillage plots, compared with the no-tillage plots for both fall and spring timings. However, densities in the third study were greater in the no-tillage plots than the conventional tilled plots for both fall timings, but were statistically equal for both systems for the spring timing.

The development of ryegrass was diverse in both tillage systems at all sampling times. The percentage of ryegrass plants that exceeded two tillers was used as a standard for comparing treatments, since this is the maximum growth stage on the labels of most postemergence herbicides used for ryegrass control. Ryegrass plants in all three studies did not exceed two tillers for the November timing in both tillage systems. Delaying herbicide treatment until mid December resulted in 3.7 to 17 percent plants with more than two tillers. The mid March timing had a larger portion of the population with greater than two tillers in the conventional till system than the no-till system.

A few ryegrass seedheads were observed at maturity in nearly all herbicide-treated plots, regardless of tillage system or timing of herbicide. The check plots of the first study had more seedheads in the conventional till plots than the no-till plots.

Ryegrass control was slower when the herbicide was applied in the fall than in the spring. Ryegrass control at the end of the season exceeded 90 percent in most instances. In a few instances, late-season control with the fall applications was 5 to 7 percent greater in no-till than conventional till plots. In some cases, late-season control increased 3 to 11 percent when the herbicide timing was delayed until mid-March. Crop injury and competition from other weeds were factors that made it difficult to determine a consistent pattern where wheat yield was affected by tillage system and timing of herbicide.

Tillage system can influence ryegrass density in some cases, yet the results may be inconsistent. Delaying applications until March resulted in more plants that exceeded the maximum label stage of two tillers, particularly in conventional till plantings. The level of ryegrass control at the end of the season exceeded 90 percent in most cases and any differences due to tillage system or timing of herbicide were minor

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FALLOW WEED CONTROL WITH SAFLUFENACIL. Brian M. Jenks, Gary P. Willoughby, and Jordan L. Hoefing, Weed Scientist and Research Specialists, North Dakota State University, Minot, ND 58701.

Saflufenacil is a new broadleaf herbicide recently registered for use in multiple crops for preplant or preemergence burndown applications, pre-harvest desiccation in sunflower, and general weed control in fallow. Summer fallow hectares in North Dakota have decreased from 688,000 hectares in 1997 to about 292,000 in 2008. The decrease in fallow hectares can be attributed to growers switching to no-till farming and the positive economic and agronomic benefits of alternative crops such as canola, dry pea, lentil, chickpea, and sunflower. Though fallow hectares have decreased, there are still enough to warrant further research to develop more cost-effective weed control alternatives.

Saflufenacil controls emerged annual broadleaf weeds and provides some residual weed control depending on rate. Studies were conducted from 2006-2009 at Minot, ND to evaluate saflufenacil, tank mix partners, and adjuvants for weed control in summer fallow.

In 2007, treatments included saflufenacil (18 g/ha) alone; glyphosate (840 g) alone; saflufenacil (25 38, and 50 g) tank mixed with glyphosate; and glyphosate (616 g) plus dicamba (154 g). These treatments were applied at 94 L/ha on June 5. Weeds consisted of kochia (2.5-20 cm, 0.5-2.3/m^2), lambsquarters (2.5-15 cm, 0.1-0.5/m^2), wild buckwheat (2.5-15 cm, 0.1-0.9/m^2), and redroot pigweed (2.5 cm, 0.1-0.4/m^2). All treatments provided ≥87% control of all weeds 4 WAT except for glyphosate applied alone, which provided only 72% control of wild buckwheat.

In 2008, treatments included saflufenacil (18 g/ha) alone; glyphosate (840 g) alone; saflufenacil (18, 25 and 50 g) tank mixed with glyphosate or dicamba (140 g); 2,4-D (560 g) plus glyphosate; and carfentrazone (9 g) plus glyphosate. These treatments were applied at 94 L/ha on June 16. To evaluate spray volume, one additional treatment of saflufenacil (25 g) plus glyphosate was applied at 47 L/ha. Weeds consisted of kochia (2.5-23 cm, 0.5-4.6/m^2), lambsquarters (2.5-18 cm, 0.2-1.4/m^2), wild buckwheat (5-8 cm, 0.1-0.3/m^2), and redroot pigweed (2.5 cm, 0-0.9/m^2). At 4 WAT, all treatments provided good to excellent control of all weeds except for saflufenacil alone at 18 g/ha. Saflufenacil alone provided approximately 45% control of wild buckwheat, kochia, lambsquarters, and redroot pigweed at 4 WAT. Between 4 and 6 WAT, new flushes of kochia, lambsquarters, and pigweed emerged. Saflufenacil at 50 g/ha provided more residual benefit compared to other treatments with ≥85% control of all weeds 6 WAT, while other treatments provided only 45-86% control of all weeds. Saflufenacil plus glyphosate at 47 L/ha generally provided 5-15% less weed control compared to 94 L/ha.

In 2009, treatments included saflufenacil (18 g/ha) alone; glyphosate (840 g) alone; saflufenacil (18 and 25 g) tank mixed with glyphosate or dicamba (140 g); 2,4-D (560 g) plus glyphosate; and carfentrazone (9 g) plus glyphosate. These treatments were applied at 94 L/ha on June 15. To evaluate spray volume, one additional treatment of saflufenacil (25 g) plus glyphosate was applied at 47 L/ha. Weeds consisted of kochia (5-30 cm, 0-0.9/m^2), lambsquarters (13-23 cm, 0-0.2/m^2), wild buckwheat (5-8 cm, 0.1-0.3/m^2), Russian thistle (8-13 cm, 0-0.4/m^2), and horseweed (13-18 cm, 0-0.2/m^2). At 4 WAT, all treatments provided ≥89% control of all weeds except for saflufenacil alone at 18 g/ha. Saflufenacil alone provided 50, 82, 86, 90, and 97% control of wild buckwheat, kochia, lambsquarters, Russian thistle, and horseweed, respectively. In contrast to 2008, saflufenacil plus glyphosate at 47 L/ha generally provided similar control to 94 L/ha.

In summary, saflufenacil at ≥25 g/ha alone or tank mixed with glyphosate provided acceptable weed control with some residual benefit at 50 g/ha. Saflufenacil alone at 18 g/ha did not provided consistent and acceptable weed control.

CROP TOLERANCE AND BROADLEAF WEED EFFICACY FOR COMBINATIONS OF THIENCARBAZONE METHYL AND TEMBOTRIONE APPLIED AT THREE CORN GROWTH STAGES. Daniel K. Tiedemann, Bryan G. Young, Ronald F. Krausz, and Joseph L. Matthews, Graduate Research Assistant, Professor, and Researchers, Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901.

The use of postemergence herbicide tank-mixtures and optimal herbicide application timings can foster more consistent weed control and contribute to an improvement in deterring the evolution of herbicide-resistant weed species. The premix of thiencarbazone-methyl (TCM) and tembotrione can be used for postemergence weed control in corn but may benefit from additional tank-mixed herbicides for the reasons cited previously. Therefore, a field study was conducted to determine the contribution of combining TCM:tembotrione with other tank-mixed herbicides and the effect of different application timings on corn response and weed control.

A field experiment was conducted at a total of three sites in 2008 and 2009 as an incomplete factorial of herbicide treatment and application timing (early-, mid-, and late-postemergence) arranged in randomized complete block with three replications. The herbicide treatments for the early postemergence (EPOST) timing were the premix of TCM:tembotrione (15:75 g ai/ha) alone and tank-mixed with atrazine (560 g ai/ha), glyphosate (860 g ae/ha), and glufosinate (450 g ai/ha) were compared with two rates of the premix TCM:isoxaflutole (20:50 g ai/ha) and (37:90 g ai/ha), and the premix of glyphosate:*s*-metolachlor:mesotrione (1,050 g ae/ha:1,050 g ai/ha:105 g ai/ha). At the mid-postemergence (MPOST) timing the premix of TCM:isoxaflutole was excluded due to label restrictions and likewise for atrazine at the late-postemergence (LPOST) timing. The EPOST, MPOST, and LPOST applications corresponded with targeted corn growth stages of V2, V4, and V6, respectively.

Corn response, primarily in the form of shortened corn internodes, was 5% or less at 7 days after treatment (DAT) for any treatment with no evidence of corn injury at 14 DAT. Near complete control of common waterhemp was observed for all herbicide combinations and application timings with the exception of the LPOST timing for TCM:tembotrione and glyphosate:*s*-metolachlor:mesotrione at one out of the three sites. The reduction in common waterhemp control for these treatments is attributed to weed heights that exceeded the herbicide limitations. The addition of glyphosate and glufosinate to TCM:tembotrione prevented any reduction in common waterhemp control at the LPOST timing. Similar to common waterhemp, control of annual morningglory was reduced when the application of TCM:tembotrione and glyphosate:*s*-metolachlor:mesotrione was delayed to the LPOST timing. However, only the addition of glufosinate, not glyphosate, to TCM:tembotrione increased control of annual morningglory at LPOST to the level observed for the earlier application timings. Control of giant ragweed was variable for the herbicide treatments over all three sites, but control was 82% or greater for any combination that included TCM:tembotrione and 90% or greater for the premix of TCM:isoxaflutole.

EFFECTS OF NITROGEN RATE AND WEED REMOVAL TIMING ON CORN YIELD.
Laura E. Bast, Wesley J. Everman and Darryl D. Warncke, Graduate Research Assistant, Assistant Professor and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Timely weed control and adequate nitrogen supply are both necessary to maximize corn grain yield and economic return. A field study was established in 2009 at the Michigan State University Agronomy Farm in East Lansing to investigate the effect of nitrogen rate and weed control timing on corn grain yield. A split-plot, randomized complete block design consisted of four preplant nitrogen application rates (0, 67, 134, and 202 kg N/ha) as main plots and six weed removal timings as subplots. Weed removal timings were defined by weed height to include control when weeds were 5, 10, 15, and 20 cm tall. Plots were maintained weed free after each weed removal timing. Two additional treatments included weed free and weedy (no weed removal) plots. At each weed removal timing, biomass samples were collected from a 0.25 m^2 area by species and fresh and dry weights recorded. Additionally, chlorophyll measurements were collected from corn ear leaves during pollination. Chlorophyll content increased with nitrogen rate and decreased with later weed removal timings. Biomass data indicated that number of weeds present at each weed removal timing was not affected by nitrogen application rate. Grain yield increased with N application rates and decreased, compared to the weed-free control, when weed control was delayed to 10 cm. Nitrogen use efficiency by corn decreased as weed removal timing increased. At the highest N rate, grain yield was the same among 0, 5, 10, 15, and 20 cm weed removal timings, indicating that grain yield loss due to delayed weed removal can be reduced with larger N application rates.

EFFECT OF POSTEMERGENCE HERBICIDES ON FIELD AND SILAGE CORN BIOMASS ACCUMULATION AND BIO-ENERGY QUALITY. Wesley J. Everman, Bradley J. Love, Jacob Gebhardt, and Andrew J. Chomas, Assistant Professor, Graduate Research Assistant, Field Research Assistant, and Research Technician, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824-1325.

Increased interest in using corn as a renewable energy source for cellulosic ethanol production raises several questions about best production practices. Several herbicides have been shown to have an adverse affect on growth of corn when applied at labeled rates. A study was established in 2008 and 2009 at the Michigan State University Agronomy Farm in East Lansing, MI to determine if postemergence herbicides labeled for use in corn affect biomass accumulation and cellulosic ethanol production. Silage and field corn hybrids were planted in a split plot design with a randomized complete block arrangement of treatments. POST applications were applied at the V4 growth stage to both silage and field corn. Herbicide treatments consisted of atrazine at 1 lb a.i./A plus COC at 1 qt/A, 2,4-D amine at 0.475 lb a.i./A, bromoxynil at 0.375 lb a.i./A, a pre-mix of dicamba plus diflufenzopyr at 0.175 lb a.i./A plus NIS at 0.25% v/v and AMS 17 lb/100 gal, mesotrione at 0.09 lb a.i./A plus COC at 1% v/v and AMS at 8.5 lb/100 gal, nicosulfuron at 0.03 lb a.i./A plus COC at 1% v/v, and a non-treated plot maintained hand weed-free. Crop injury, height and stage measurements were taken every 2 weeks following herbicide application. Injury was observed in plots treated with 2,4-D and bromoxynil in both the field and silage corn hybrids. Corn heights and biomass yield differences at the end of the season were dependent upon hybrid.

COMPARISON OF POSTEMERGENCE HERBICIDES IN CORN WITH RESISTANCE TO GLYPHOSATE AND GLUFOSINATE. Mark M. Loux, Anthony F. Dobbels, William G. Johnson, Bryan G. Young, Chris Boerboom, Kevin Bradley, and Aaron Hager, Professor and Research Associate, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43221, Associate Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907, Professor, Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901, Professor, Department of Agronomy, University of Wisconsin, Madison, WI 53706, Assistant Professor, Division of Plant Sciences, University of Missouri, Columbia, MO 65211, and Associate Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Glyphosate-resistant corn is now the predominant type of corn grown in the Midwestern United States, and many glyphosate-resistant corn hybrids are also resistant to glufosinate. While the price of glyphosate is currently low, a weed management system based on use of glyphosate-resistant hybrids and glyphosate may not be the most economical choice for some corn growers, due to differences in seed costs and the availability of other effective and economical POST corn herbicides. A primary objective of this research was to determine whether similar weed control and crop yield occurs when other POST herbicides are substituted for glyphosate in corn resistant to glyphosate and glufosinate.

A field study was conducted at a total of 11 sites in 2008 and 2009 to determine the effectiveness of four POST herbicide systems in corn resistant to glyphosate and glufosinate. POST herbicide systems included: glyphosate (840 g ae/ha); glufosinate (450 g/ha)/atrazine (560 g/ha); tembotrione (92 g/ha)/atrazine (560 g/ha); and rimsulfuron (13 g/ha)/nicosulfuron (26 g/ha)/dicamba (84 g/ha)/diflufenzopyr (34 g/ha). The two types of herbicide applications in the study were: 1) EPO - early POST application of a combination of POST and residual herbicides, when weeds were less than 7 cm tall; and 2) PRE/POST - application of residual herbicides at the time of corn planting, followed by POST herbicide application when corn was about 18 inches tall. The study was a 3-way factorial, where the factors were type of application, residual herbicide, and POST herbicide system. The residual herbicides were preformulated combinations of atrazine and s-metolachlor, or atrazine, s-metolachlor, and mesotrione. These were applied at 67% of the typical labeled rate for the soil type. Weed control was determined at the time of and 21 days after POST application, and just prior to corn harvest. This abstract includes late-season weed control and grain yield results from 2008 only, because data from all of the 2009 sites was not yet available at the time of abstract preparation.

Control of several weeds exceeded 90% at the end of the 2008 season regardless of treatment. Weeds in this group included velvetleaf, common lambsquarters, wild sunflower, yellow foxtail, redroot pigweed, ivyleaf morningglory, barnyardgrass, large crabgrass, and Pennsylvania smartweed. Weeds for which control exceeded 80% included common ragweed, common cocklebur, giant foxtail, and prickly sida. The following weeds were more effectively controlled by the PRE/POST than the EPO application, by a margin of 3 to 9%, when control was averaged over other factors: giant foxtail, tall waterhemp, common cocklebur, common ragweed, and tall morningglory. Tall waterhemp, common cocklebur, common ragweed, and tall morningglory were most effectively controlled where the residual herbicide was atrazine, s-metolachlor, and mesotrione.

POST herbicide affected control of only four weeds at the end of the 2008 season. Control of giant foxtail was similar for glyphosate and rimsulfuron/nicosulfuron/dicamba/diflufenzopyr (96%), but reduced by 3 to 5% for glufosinate and tembotrione/atrazine, respectively. Control of fall panicum exceeded 95% for all treatments except tembotrione/atrazine, for which the control averaged over other factors was 67%. Control of tall waterhemp and common ragweed exceeded 90%, averaged over other factors, but tembotrione/atrazine was more effective than the other herbicides for control of waterhemp, and rimsulfuron/nicosulfuron/dicamba/diflufenzopyr was less effective then the others for control of common ragweed. Corn yield in 2008 was not affected by residual or POST herbicide, but was affected by type of herbicide application. The yield for the PRE/POST application was 5 bushels higher than the EPO, averaged over other factors.

INTERACTIONS BETWEEN SAFLUFENACIL AND GLYPHOSATE ON SELECTED BROADLEAF WEEDS. Stevan Z. Knezevic, Avishek Datta, Jon Scott*, and Leo D. Charvat. Associate Professor, Postdoctoral Research Associate, Research Technologist, Haskell Agricultural Laboratory, University of Nebraska, Concord, NE 68728; Biology Area Manager, BASF Corporation, Lincoln, NE 68523.

Saflufenacil (Kixor™) is a new herbicide under development by BASF for preplant burndown and preemergence broadleaf weed control in field crops, including corn, soybean, sorghum, and wheat. Field experiments were conducted in 2007 and 2008 to describe dose-response curves of saflufenacil applied alone or tank-mixed with methylated seed oil (MSO) or glyphosate to control several broadleaf weeds in Nebraska. Dose-response curves based on log-logistic model were used to determine the ED_{90} values (effective dose that provides 90% weed control efficacy) for kochia, wild buckwheat, horseweed, henbit, field pennycress, prickly lettuce, shepherd's-purse, field bindweed, and dandelion. In general, weed control efficacy was influenced by herbicide dose and type of tank-mix. For most of the species tested, weed control efficacy increased when small amount of saflufenacil was added to the label dose of glyphosate. For example, 90% control of horseweed at 28 days after treatment was obtained with 217, 78, and 35 g ai/ha for saflufenacil applied alone or tank-mixed with MSO or glyphosate, respectively. The ED_{90} values determined for different broadleaf weed species are within the proposed label dose for saflufenacil (e.g., 125 g ai/ha). Addition of glyphosate improved activity; however, it may not be needed unless grass and perennial weeds are target species.
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UTILIZATION OF FLUMIOXAZIN IN MIDWESTERN MINIMUM AND NO-TILL CORN. Eric J. Ott, Dawn E. Refsell, Trevor M. Dale and John A. Pawlak, Field Market Development Specialists, Product Development Manager, Valent USA Corporation, Walnut Creek, CA 94596.

Flumioxazin is a protoporphyrinogen oxidase (PPO) inhibiting herbicide which as been registered for use in wide range of crops in the Midwest. Flumioxazin recently received registration for use in no-till and minimum till field corn production up to 14 days prior to planting at a use rate of 0.064 lb ai/A in 2009.

Eight trials were conducted across the north-central United States in 2009 in no-till glyphosate-resistant field corn. Early pre-plant (EPP) were applied 14 days prior to planting. Treatments included; 1) EPP glyphosate (0.77 lb ae/A) followed by POST glyphosate (0.77 lb ae/A), 2) EPP flumioxazin (0.064 lb ai/A) + glyphosate (0.77 lb ae/A) followed by POST glyphosate (0.77 lb ae/A) + atrazine (1 lb ai/A), 3) EPP flumioxazin (0.064 lb ai/A) + atrazine (1 lb ai/A) + glyphosate (0.77 lb ae/A) followed by POST glyphosate (0.77 lb ae/A), 4) EPP s-metolachlor (0.87 lb ai/A) + atrazine (0.87 lb ai/A) + mesotrione (0.112 lb ai/A) followed by POST glyphosate (0.77 lb ae/A).

An EPP application of flumioxazin (+/- atrazine EPP) controlled foxtail species and morningglory species similar to that of an EPP application of s-metolachlor + atrazine + mesotrione, and significantly better than an EPP application of glyphosate at the time of the POST glyphosate application. Flumioxazin treatments controlled velvetleaf significantly better than the glyphosate alone applied at EPP, but control was significantly less than the s-metolachlor + atrazine + mesotrione treatment at the time of the POST glyphosate application. Adding EPP atrazine 1 lb ai/A to flumioxazin controlled velvetleaf similarly to s-metolachlor + atrazine + mesotrione. Flumioxazin EPP treatments controlled foxtail species, common lambsquarters, velvetleaf, common waterhemp, and morningglory species similar to s-metolachlor + atrazine + mesotrione 14 days after the POST glyphosate application, and controlled the previously mentioned weeds significantly better than the EPP glyphosate application followed by a POST glyphosate application.

A 14 day pre-plant application of flumioxazin plus glyphosate provides broad spectrum residual weed control, controls many glyphosate resistant weeds, provides crop rotational flexibility to corn or soybeans, and allows for POST use of atrazine premix products with glyphosate for extended in-season residual control.

PERFORMANCE OF DOW AGROSCIENCES HERBICIDE TOLERANCE TRAIT IN CORN. Mark A. Peterson, David M. Simpson, Cory Cui, Eric F. Scherder, David C. Ruen, John S. Richburg, Sam M. Ferguson, Patricia L. Prasifka and Terry R. Wright, Dow AgroSciences, Indianapolis, IN 46268.

Dow AgroSciences has introduced two new herbicide tolerance traits, commonly referred to Dow AgroSciences Herbicide Tolerance (DHT) traits. DHT1 trait is currently being developed in corn. The DHT1 trait is a synthetic gene developed by Dow AgroSciences from *Sphingobium herbicidovrans*. *In planta* this gene produces an enzyme that metabolizes several herbicides having an aryloxyalkanoate moiety, including Phenoxy auxins (e.g., 2,4-D, MCPA) and aryloxyphenoxypropionates (e.g., quizalofop, haloxyfop). DHT1 corn events have been tested in the field and demonstrated robust tolerance to preemergence, single postemergence, and sequential postemergence applications of 2,4-D at 1120, 2240 and 4480 g ae/ha. Postemergence applications of quizalofop of up to 184 g ai/ha have also been well tolerated by DHT1 corn events. Corn growth, development, maturity and yield of individual events are equivalent to iso-lines. DHT1 may also be stacked with other herbicide resistance traits to improve and enhance the performance of current weed control systems, improve the control of “hard to kill” broadleaf weeds, and prevent or delay the onset of herbicide resistant weeds.

EVALUATION OF THE POTENTIAL FOR AN ORGANOPHOSPHATE INTERACTION IN OPTIMUM® GAT® CORN VERSUS CONVENTIONAL GLYPHOSATE TOLERANT CORN. Kevin R. Schabacker*, Larry H. Hageman, Charles E. Snipes and David W. Saunders, DuPont Crop Protection, Rochelle, IL 61068.

Increased corn injury with an In-Furrow (IF) application of a granular organophosphate insecticide followed by pre and postemergence sulfonylurea herbicides has been documented in field trials. The possibility of this organophosphate interaction has mandated label restrictions on In-Furrow and tank mix insecticide + sulfonylurea herbicide treated corn plants. Optimum® GAT® corn contains a transgenic ALS gene, a highly resistant allele with two mutations, that confers resistance to ALS herbicides.

Field Studies were conducted to evaluate the potential for Optimum® GAT® corn to avoid the organophosphate-sulfonylurea interaction. Corn was planted, along with In-Furrow applications of terbufos 15G, in light soils at two locations. Preemergence herbicide treatments were made immediately after planting. Postemergence applications of sulfonylurea herbicides alone or in tank mix with chlorpyrifos, were made to 4-collar corn. Visual injury was rated at 7, 14 and 28 days after post treatment (DAT).

Optimum® GAT® corn showed excellent tolerance to all treatments at 7, 14 and 28 DAT.

Conventional glyphosate tolerant corn showed little to no tolerance to the sulfonylurea tank mixes, the granular insecticide followed by sulfonylurea sequential applications, or the chlorpyrifos + sulfonylurea post tank mixes as the corn was severely injured by all treatments at 7, 14 and 28 DAT.

This research demonstrates the potential for the use of terbufos 15G soil insecticide when followed by sulfonylurea herbicides or tank mix applications of chlorpyrifos with post applied sulfonylurea herbicides when used on Optimum® GAT® corn.

OPTIMUM® GAT® CORN IN KENTUCKY. Sara K. Carter, Charles H. Slack and Helen A. Flanigan. Research Analyst and Research Specialist, University of Kentucky, Lexington, KY 40546-0312, Product Development Manager, DuPont Crop Protection, Wilmington, DE 19880-0705.

Trials have been conducted at the University of Kentucky's Spindletop Research Facility, Lexington, evaluating weed control measures utilizing the OPTIMUM® GAT® technology. Herbicides observed included combinations of rimsulfuron, chlorimuron ethyl and mesotrione (Instigate™), rimsulfruon, tribenuron-methyl and mesotrione (Trigate™) and thifensulfuron-methyl, tribenuron-methyl and chlorimuron-ethyl (Freestyle™). Treatments were applied preemergence and mid-postemergence. Weed species present included giant foxtail, smooth pigweed, common cocklebur and morning glory. All were ≥ 92% controlled two weeks after the mid-post application and ≥ 89% controlled four weeks after the application. There was no crop injury observed.

COCKLEBUR CONTROL IN CORN. Peter H. Sikkema, Christy Shropshire and Nader Soltani. Department of Plant Agriculture, University of Guelph Ridgetown Campus, Ridgetown, ON N0P 2C0.

Nine field trials (5 with PRE- and 4 with POST-emergence herbicides) were conducted in 2006 to 2009 on various Ontario farms with heavy infestations of cocklebur to determine the effectiveness of PRE- and POST-emergence herbicides for the control of cocklebur in corn. There was no commercially significant injury in corn from the PRE herbicides evaluated. Saflufenacil, saflufenacil/dimethenamid-p, isoxaflutole + atrazine and mesotrione + atrazine, applied PRE provided 85, 85, 76 and 73% control of cocklebur in corn, respectively. Cocklebur shoot dry weight was reduced 84, 80, 79, 75 and 68% with saflufenacil/dimethenamid-p, isoxaflutole + atrazine, mesotrione + atrazine, saflufenacil and dicamba/atrazine, respectively. There was no effect on yield with the PRE herbicides evaluated.
The application of 2,4-D/atrazine resulted in unacceptable injury (28%) in corn. Dicamba/atrazine, dicamba/diflufenzopyr, dicamba and mesotrione + atrazine all proved 90% or greater control of cocklebur. Dicamba, dicamba/atrazine, dicamba/diflufenzopyr and primisulfuron/dicamba reduced cocklebur dry weight to zero in these experiments. All POST herbicide treatments increased corn yield compared to the non-treated check. Saflufenacil and saflufenacil/dimethenamid-p applied PRE and dicamba, dicamba/diflufenzopyr, dicamba/atrazine and mesotrione + atrazine applied POST have potential to provide good to excellent control of cocklebur in corn under Ontario environmental conditions.

HERBICIDE EFFICACY ON FIELD HORSETAIL IN NO-TILL CORN. Bryan M. Jensen, Chris M. Boerboom, and Tim L. Trower, IPM Program Manager, Professor, and Senior Outreach Specialist, University of Wisconsin, Madison 53706.

No-till corn growers report that infestations of field horsetail are increasing and that this perennial weed is not controlled with standard burndown herbicides such as glyphosate or 2,4-D. Previous research indicated flumetsulam applied as a burndown treatment or postemergence treatments that include a mixture of an ALS-inhibiting herbicide with a growth regulating herbicide provide better field horsetail control. Based on this information, a field study was conducted to evaluate several burndown and postemergence treatments at two sites, located in Monroe and Columbia counties, WI. Burndown herbicide treatments for field horsetail control included flumetsulam at 0.05 lb ai/a and saflufenacil at 0.07 lb ai/a applied alone and in combination compared against glyphosate at 0.75 lb ae/a plus 2,4-D at 0.5 lb ae/a. Postemergence treatments included rimsulfuron:nicosulfuron at 0.01:0.02 lb ai/a plus dicamba:diflufenzopyr at 0.13:0.05 lb ae/a; rimsulfuron:nicosulfuron at 0.01:0.02 lb/a plus flumetsulam:clopyralid at 0.05 lb/a:0.13 lb ae/a; dicamba:diflufenzopyr at 0.13:0.05 lb/a plus glyphosate at 0.75 lb/a; halosulfuron:carfentrazone at 0.03:0.008 lb ai/a; dicamba:halosulfuron at 0.13:0.03 lb/a; and tembotrione plus atrazine at 0.08 lb ai/a and 0.5 lb ai/a. Sequential treatments of flumetsulam followed by glyphosate and saflufenacil followed by glyphosate were also evaluated. All treatments included label recommended adjuvants. These treatments were selected to evaluate active ingredients from six different modes of action. Burndown treatments were applied on May 14, 2009 at Monroe County and May 11, 2009 at Columbia County to field horsetail sterile shoots that were up to 10 cm tall. Postemergence treatments were applied on June 9 and 12, respectively, to 20 cm tall shoots when corn was at the V3 stage. All treatments included preemergence residual herbicides to control annual weeds.

In the burndown treatments at Monroe County, flumetsulam suppressed field horsetail growth by 55% at 2 weeks after treatment (WAT) and control increased to 70% by 8 WAT. Saflufenacil caused horsetail shoots to become necrotic with 80% control at 2 WAT, but control decreased to 13% control by 8 WAT. The combination of both herbicides increased control to 94% at 2 WAT, but control declined to 49% at 8 WAT. Control from the standard treatment of glyphosate plus 2,4-D declined from 50% at 2 WAT to 0% at 8 WAT. All burndown treatments were less effective at the Columbia County site than at Monroe County despite some early suppression. Flumetsulam and saflufenacil gave 13 and 0% horsetail control at 8 WAT at Columbia County.

The postemergence rimsulfuron:nicosulfuron plus dicamba:diflufenzopyr treatment at Monroe County provided excellent (98%) horsetail control at 4 WAT. Rimsulfuron:nicosulfuron plus flumetsulam:clopyralid, dicamba:diflufenzopyr plus glyphosate, and dicamba:halosulfuron provided moderate suppression of horsetail that ranged from 63 to 76% at 4 WAT. Halosulfuron:carfentrazone and tembotrione plus atrazine only gave minimal horsetail suppression. Postemergence treatment with glyphosate after a burndown application of flumetsulam did not increase control compared to flumetsulam alone at 8 WAT, but a postemergence glyphosate treatment after saflufenacil moderately increased the suppression over saflufenacil alone. While the postemergence treatments at Columbia County followed the general pattern of efficacy as the treatments at Monroe County, they were significantly less effective and no treatment gave greater than 40% control by 4 WAT.

Corn yields with the most effective burndown and postemergence treatments at Monroe County were 140 bu/a after flumetsulam and 120 bu/a after rimsulfuron:nicosulfuron plus dicamba:diflufenzopyr and exceeded the 59 bu/a corn yield of the control treatment. Corn yields did not differ among treatments at the Columbia County site, which was likely a result of the poor control. The reason for the greater efficacy at Monroe County is unknown. It may relate to a difference in biotypes or in the age of the infestation where the Monroe County site may be younger and more sensitive. Weather differences between the sites may have existed although significant differences did not seem apparent. The more successful field horsetail treatments should be evaluated in future years to determine their consistency.

KOCHIA CONTROL WITH SELECTED HERBICIDES IN SOYBEANS. Brandon M. Hulse, Kassim Al-Khatib, Phillip W. Stahlman, Dallas E. Peterson, and Patrick W. Geier, Graduate Research Assistant, Professor, Professor, Professor, and Assistant Scientist, Department of Agronomy, Kansas State University, Manhattan, KS, 66506.

Field experiments were conducted during the summer of 2009 at Hays in northwest Kansas, and near Cimarron in southwest Kansas to evaluate kochia control with selected herbicides in soybeans. Preemergence treatments consisted of flumioxazin at 72 and 108 g ai/ha, flumioxazin + clorimuron ethyl at 415 + 248 g ai/ha, sulfentrazone at 213 and 314 g ai/ha, sulfentrazone + cloransulam-methyl at 34 + 258 g ai/ha, S-metolachlor + fomesafen at 1099+280 g ai/ha, metribuzin + sulfentrazone at 303 + 202 g ai/ha, and metribuzin at 426 g ai/ha, clomazone at 841 g ai/ha, pendimethalin at 1.5 g ai/ha, imazaquin at 140 g ai/ha. In addition, 4 weeks after PRE treatments, glyphosate was POST applied at 841 and 1642 g ai/ha when kochia was 6-8cm tall. Kochia was evaluated 14, 28, 42, 56, and 70 days after treatment (DAT). All herbicide treatments provided greater than 95% control of kochia except flumioxazin 28 DAT. However, at 42 DAT all treatments provided more than 90% kochia control with sulfentrazone and sulfentrazone+cloransulam-methyl providing greatest control. Glyphosate controlled less than 95% of kochia at 56 DAT and less than 65% of kochia at 70 DAT. This research showed that glyphosate applied alone did not provide adequate long season kochia control. Therefore, preemergence herbicide treatment is critical when kochia is present in any field.

IMPACT OF LATE HERBICIDE APPLICATIONS IN SOYBEAN. Nader Soltani[1], Robert E. Nurse[2] and Peter H. Sikkema[1]. [1]Department of Plant Agriculture, University of Guelph Ridgetown Campus, Ridgetown, ON; [2]Greenhouse and Processing Crops Research Centre, Agriculture and Agri-Food Canada, Harrow, ON

Three field trials were conducted between 2007 and 2009 in Ontario to evaluate the response of soybean to various postemergence herbicides applied beyond their recommended application timing (five trifoliate to early flowering growth stage). The application of glyphosate as a single (1X) and overlap (2X) application caused no injury in soybean. There was no decrease in plant height. Yield was reduced by 3% at the overlap rate. Imazethapyr caused 4 to 15% injury and decreased height and yield up to 11%. Chlorimuron-ethyl caused 3 to 8% injury, reduced height up to 7% and decreased yield up to 5%. Thifensulfuron-methyl caused 20 to 32% injury, reduced height up to 17%, and decreased yield up to 11%. Cloransulam-methyl caused 5 to 7% injury, reduced height up to 5% but had no effect on yield. Fomesafen caused 1 to 3% injury, had no effect on height but decreased yield 3% at both the 1X and 2X rate. Bentazon caused 1 to 2% injury, had no effect on height but decreased yield 3% at the 2X rate. Quizalofop-p-ethyl caused up to 1% injury and had no effect on height or yield of soybean. Based on these results, there is an adequate margin of crop safety in soybean to the late application of glyphosate, chlorimuron-ethyl, cloransulam-methyl, bentazon and quizalofop-p-ethyl when applied at the manufacturer's recommended rate.

EVALUATION OF HERBICIDE PROGRAMS FOR THE CONTROL OF VOLUNTEER GLYPHOSATE-RESISTANT AND GLUFOSINATE-RESISTANT CORN IN GLUFOSINATE-RESISTANT SOYBEAN. Travis R. Legleiter, Eric B. Riley, Jimmy D. Wait, Kristin K. Payne, and Kevin W. Bradley, Senior Research Specialist, Research Specialist, Research Associate, Graduate Research Assistant, Associate Professor, Division of Plant Sciences, University of Missouri, Columbia, MO 65211.

A field experiment was conducted during 2009 to evaluate herbicide programs for the control of volunteer glyphosate-resistant and glufosinate-resistant corn in glufosinate-resistant soybeans. All treatments were arranged in a randomized complete block design with four replications and were applied at two separate timings; when the average size of volunteer corn reached either 30- or 60-cm in height. Just prior to soybean planting, four rows of glyphosate-resistant and glufosinate-resistant corn were planted in each plot perpendicular to the direction of the soybean rows. All weeds other than volunteer corn were removed from the experimental area for the duration of the experiment. Treatments included glufosinate at 0.45, 0.59, and 0.74 kg/ha, glufosinate at 0.45 kg/ha plus clethodim, fluazifop-P, quizalofop-P, and imazaquin at rates recommended for either 30- or 60-cm tall volunteer corn, and also clethodim, fluazifop-P, quizalofop-P, and imazaquin at rates recommended for either 30- or 60-cm tall volunteer corn applied without glufosinate. Late-season counts of volunteer glyphosate-resistant and glufosinate-resistant corn plant density revealed that much higher control of glyphosate- and glufosinate-resistant corn was achieved at the 30 compared to the 60-cm application timing. Applications of 0.45, 0.59, or 0.74 kg/ha glufosinate alone at either application timing provided no reductions in glufosinate-resistant corn plants. However, all rates of glufosinate provided almost complete elimination of glyphosate-resistant corn at the 30-cm application timing, but only slight reductions in the density of glyphosate-resistant corn when applied at the 60-cm application timing. Glufosinate was not antagonistic to clethodim, quizalofop-P, fluazifop-P, or imazaquin at either the 30- or 60-cm application timing. Soybean yields ranged from 3638 to 3997 kg/ha among all treatments and there were few differences between herbicide-treated or untreated plots. Results from these experiments indicate that applications of glufosinate alone can provide good control of volunteer glyphosate-resistant corn less than 30-cm in height and that glufosinate can be applied in combination with clethodim, quizalofop-P, fluazifop-P, and imazaquin for the control of volunteer glyphosate- or glufosinate-resistant corn in glufosinate-resistant soybean.

EFFICACY OF GLUFOSINATE PLUS FOMESAFEN MIXTURES ON GIANT RAGWEED, COMMON LAMBSQUARTERS AND VOLUNTEER CORN. Chad B. Brabham and William G. Johnson, Graduate Student and Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Giant ragweed (*Ambrosia trifida*), common lambsquarters (*Chenopodium album*) and glyphosate resistant volunteer corn (*Zea mays*) are commonly found in Midwest soybean fields after POST glyphosate application. Glufosinate has recently become a viable alternative to glyphosate but with varying effectiveness on broadleaf weeds the addition of fomesafen to glufosinate could increase overall control. Two field studies near Lafayette, IN were conducted in 2009 to determine the effectiveness of fomesafen and glufosinate tank mixtures on the aforementioned weeds ranging from 10 to 20 cm in height. Glufosinate was applied alone, sequentially or with fomesafen (Flexstar) at 0.0, 0.061, 0.122, 0.183, 0.244, 0.305, 0.61, and 1.22 lbs ai/a. At 21 days after treatment height and dry weights were recorded for individual harvested plants. Data were subjected to a joint analysis and lsmeans were compared to determine the effects of treatments. Fomesafen rates greater than 0.244 lbs/a and treatments with glufosinate controlled giant ragweed 89 to 99%. All treatments with glufosinate were highly effective on corn. Control of common lambsquarters with fomesafen did not exceed 30%, however, the addition of glufosinate reduced height and weight by at least 70%. Treatments of glufosinate plus fomesafen at 0.061 and 0.183 lbs/a or a sequential glufosinate application provided the best overall control of all species and ranged from 80 to 100%. Tank mixtures resulted in mainly an additive response, but antagonism did occur on common lambsquarters with fomesafen at rates of 0.122, 0.305 and 1.22 lbs/a mixed with glufosinate. Tank mixtures could be effective where giant ragweed and volunteer corn are problematic while sequential treatments of glufosinate may be needed to control common lambsquarters.

OPTIMAL ACTIVATOR ADJUVANTS FOR GLYPHOSATE TANK-MIXTURES IN SOYBEAN.
David K. Powell, Bryan G. Young, Douglas J. Maxwell, and Gordon K. Roskamp, Graduate Research Assistant, Professor, Southern Illinois University, Carbondale, IL 62901, Principal Research Specialist, University of Illinois, Urbana, IL 61801, and Professor, Western Illinois University, Macomb, IL 61455.

Field studies were conducted in a total of eight locations in Illinois over 2008 and 2009 to determine the role of adjuvants in tank-mixtures of broadleaf herbicides with glyphosate. Field locations included a site with glyphosate-resistant common waterhemp and two sites with PPO-resistant common waterhemp. Common waterhemp susceptible to glyphosate and PPO-inhibiting herbicides was evaluated at a total of five sites. Glyphosate was formulated the potassium salt with a full surfactant load and was applied alone (860 g ae/ha) and in combination with lactofen (105 and 210 g ai/ha) or fomesafen (165 and 330 g ai/ha). The five adjuvants evaluated included: no additional adjuvant; nonionic surfactant (NIS) at 0.5% v/v; crop oil concentrate (COC) at 1.0% v/v; petroleum oil-based high surfactant oil concentrate (PO-HSOC) at 0.5% v/v; and seed oil-based high surfactant oil concentrate (SO-HSOC) at 0.5% v/v.

Soybean injury at 7 DAT was influenced by the interactions of the tank-mix herbicide with adjuvant or with herbicide rate. The addition of any adjuvant with lactofen increased soybean injury up to 30% compared with no adjuvant (23%); whereas only the addition of NIS and SO-HSOC increased soybean injury from fomesafen to a maximum of 19%. The increase in soybean injury was 5% or less from applying the higher rates of lactofen and fomesafen compared with the lower herbicide rates. At 14 and 28 DAT soybean injury had dissipated to 10 and 4% or less, respectively, with the injury related mostly to the herbicide and application rate and relatively less association with adjuvant. Control of glyphosate-susceptible and PPO-resistant common waterhemp was 96% or greater at 14 DAT for all herbicide and adjuvant combinations which suggests a significant tendency for glyphosate to be antagonized by lactofen, fomesafen, or the adjuvants was not evident in these trials. Control of glyphosate-resistant waterhemp was 67% with glyphosate applied alone at 14 DAT. The addition of lactofen, fomesafen, or various adjuvants to glyphosate did not result in any statistical increase in control of glyphosate-resistant waterhemp.

This research demonstrates that combining glyphosate with other herbicides or adjuvants for improved control of herbicide-resistant and -susceptible common waterhemp may not provide a large impact on overall control. Furthermore, this may suggest that postemergence tank-mixtures with glyphosate should not be the primary practice implemented in herbicide-resistant weed management strategies for common waterhemp in lieu of more effective options such as residual herbicides.

PERFORMANCE OF DOW AGROSCIENCES HERBICIDE TOLERANCE TRAIT IN SOYBEAN.
David M. Simpson, Dave C. Ruen, Eric F. Scherder, Mark A. Peterson, Scott C. Ditmarsen, Jeff M. Ellis, John S. Richburg, Drew T. Ellis, Dow AgroSciences, 9330 Zionsville Road, Indianapolis, IN 46268.

Dow AgroSciences has introduced two new herbicide tolerance traits, commonly referred to as Dow AgroSciences Herbicide Tolerance (DHT) traits. One of these traits, DHT2 is currently being developed in soybean (Glycine max L.). The DHT2 trait is a synthetic gene developed by Dow AgroSciences from Delftia acidovorans. In planta, this gene produces an enzyme that metabolizes several herbicides having an ayloxy-alkanoate moiety, including Phenoxy auxins (e.g., 2,4-D, MCPA). DHT2 soybean events with low to high expression levels have been tested in the field. Robust tolerance to preemergence or single postemergence or sequential postemergence applications of 2,4-D at 1120, 2240 and 4480 g ae/ha have been observed regardless the level of expression. Soybean growth, development, maturity and yield of individual events are equivalent to iso-lines. This technology will allow 2,4-D to be applied from burndown through the R2 growth stage in DHT2 soybean. The DHT2 trait may also be stacked with glufosinate and glyphosate tolerance traits in soybean to improve and enhance the performance of glyphosate & glufosinate cropping systems, improve the control of “hard to kill” broadleaf weeds, reduce selection pressure for glyphosate resistance and sustain the glyphosate cropping system.

THE EFFECT OF NOZZLE TYPE AND APPLICATION VOLUME FOR ANNUAL WEED CONTROL IN LIBERTY-LINK SOYBEANS WITH GLUFOSINATE.
David A. Nicolai and Jeffrey L. Gunsolus, Regional Extension Educator and Extension Specialist, Department of Agronomy and Plant Genetics, 1991 Upper Buford Circle, 411 Borlaug Hall, St. Paul, MN 55108-6026

This study was conducted in Liberty-Link soybeans to evaluate glufosinate herbicide efficacy at two locations in Minnesota, comparing a conventional nozzle, one chamber type nozzle, and two low-drift air induction nozzles at two water volume rates. The nozzle comparisons included an extended range flat-fan nozzle (XR flat-fan) from Spraying Systems, the chamber style turbo flat-fan from Spraying Systems (TT); a pre-orifice/venturi air induction flat-fan (AIXR) from Spraying Systems and a venturi/air induction GuardianAir (GA) from Hypro. The nozzle treatments delivered spray volumes of 10 and 15 gallons per acre while maintaining fine, medium and coarse size droplets.

A field experiment was conducted the summer of 2009 at the Southwest Research and Outreach Center in Lamberton, MN and the Southern Research and Outreach Center in Waseca, MN. The experimental design was a randomized complete block design with treatments arranged in a 2 by 4 factorial consisting of spray volume by spray tip design. Treatments were replicated four times and efficacy was evaluated at 10 and 30 days after treatment. Soybean yield was measured for each treatment and final was adjusted to 13% moisture. The soybean varieties MBS Genetics SG2378LL and S080137LL were planted on May 19th at Lamberton and May 28th at Waseca respectively in 30 inch wide rows at 160,000 seeds per acre. The applications were made on June 20th at Lamberton and on June 26th at Waseca with a tractor-mounted 3-point sprayer equipped with a 4 nozzle boom. Nozzles were spaced at 15 inches and located 20 inches above the target. Glufosinate (Ignite 280 SL herbicide) at 22 oz/acre with AMS at 3.0 lbs/acre was applied to 4 - 6 inch or smaller common lambsquarters, common waterhemp, redroot pigweed, barnyard grass, giant foxtail and green foxtail, depending on location. Soybeans were at the V3 leaf stage and approximately 5 inches in height at the time of herbicide application. Air temperatures were 83^{o}F at Waseca and 73^{o} F at Lamberton at the time of application. The operating pressure of 40 psi for each nozzle treatment was selected to deliver spray volumes of 10 and 15 gallons per acre while maintaining fine, medium and coarse size droplets. The flow rates were attained by selecting the following manufacturers spray tip orifice sizes: XR11015, XR11002, TT11015, TT11002, AIXR110015, AIXR11002, GA110015 and GA11002. Analysis: Data was subjected to ANOVA and means were separated with Fisher's protected LSD ($P \leq .10$).

Data were analyzed separately by location. At Waseca, at the 10 gpa rate, lambsquarter control from the AIXR nozzle tip was was significantly less than the XR tip. At the 15 gpa rate, TT nozzle tip was significantly less than both the XR and GA tips. Control of Amaranth species (redroot pigweed and waterhemp) was similar for all nozzle types at both locations except for the AIXR spray tips which provided reduced control at the 10 gpa rate at Waseca. When averaged over nozzle types, Amaranth efficacy ratings at Lamberton provided significantly better control at the 15 gpa rate compared to the 10 gpa rate 91% versus 89% control (at p = 0.01). There were no significant differences among spray tips for the control of a mixed grass species (Green Foxtail and Barnyard Grass) at either the 10 or 15 gpa rates at Lamberton. Giant Foxtail control at Waseca was similar for all nozzle types except control was lower for the XR spray tip compared to the GA tip at the 15 gpa rate. No significant interactions were found among nozzle and spray-volume variables at either Waseca or Lamberton. Waseca soybean yields were not significantly different either among spray tips or spray volumes. When averaged across spray volume, Lamberton soybean yields were lowest for the GA nozzle tip (at p = 0.10).

The wide-spread use of glyphosate tolerate soybeans has increased the use of drift-reduction nozzles. Applicators who currently use nozzles designed to reduce drift while maintaining adequate efficacy for glyphosate, could use "drift-reduction" style nozzles with glufosinate and not experience significant reductions in weed control or soybean yield loss. The risk of a reduction in soybean yield with the use of "drift-reduction" nozzles will decline even more if growers adopt a sequential weed control program of a soil applied herbicide followed by a glufosinate herbicide application or the use of two multiple applications of gulfosinate applied postemergence.

SIMULATED DICAMBA DRIFT ON A LOW SOYBEAN PLANT POPULATION. Matthew J. Hardebeck, Andrew P. Robinson and William G. Johnson. Undergraduate Student, Graduate Research Assistant and Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Increasing soybean seed price and earlier planting have resulted in reduced plant populations. In addition, the introduction of dicamba-resistant soybean may increase the use and off-target movement of dicamba. The objective of this research was to quantify crop injury and yield of glyphosate-resistant soybean in a low population treated with dicamba. Becks brand 342NRR soybean was drilled at 225,000 seeds ha^{-1} and 10 treatments of dicamba (0, 0.05675, 0.0227, 0.5675, 1.135, 2.27, 4.54, 9.08, 22.7, and 454 g ae ha^{-1}) were applied at 3 timings (V2, V5, and R2) in Lafayette, IN. Visual ratings of injury and growth inhibition were recorded at 7, 14, 21, 28, and 42 days after treatment. Across timings, crop injury and growth inhibition were the greatest at 21 and 28 days after treatment. Comparing 21 to 28 days after treatment, crop injury decreased at the V2 timing and increased at the V5 and R2 timings. Growth inhibition was greatest at 21 days after treatment for the V2 timing, followed by R2, then V5. Yield will be reported.

SIMULATED DICAMBA DRIFT ON ROUNDUP-READY SOYBEAN. Andrew P. Robinson and William G. Johnson, Graduate Research Assistant and Professor, Department of Botany and Plant Pathology, Purdue University, 915 W. State St., West Lafayette, IN 47907.

New trait technologies incorporating dicamba tolerance in soybean will increase the use of dicamba causing a greater potential for drift and redeposition. Our objective was to quantify crop injury and yield loss from dicamba drift on glyphosate-tolerant soybean. Ten rates (0, 0.05675, 0.0227, 0.5675, 1.135, 2.27, 4.54, 9.08, 22.7 and 454 g ae ha^{-1}) were applied at three timings (V2, V5 and R2) on Becks brand 342NRR soybean planted at Lafayette and Fowler, IN. Soybean was most sensitive to dicamba drift when it occurred at V5 and R2. Soybean had a greater recovery from the V2 timing than V5 and R2 applications, but this may be due to a longer period of time to overcome the damaging effects of dicamba. Yield will be reported.

SOYBEAN RESPONSE TO SIMULATED DIFLUFENZOPYR & DICAMBA & ISOXADIFEN-ETHYL DRIFT. Damian D. Franzenburg, Micheal D.K. Owen, James F. Lux and Dean Grossnickle, Agricultural Specialist, Professor and Agricultural Specialists, Department of Agronomy, Iowa State University, Ames, IA 50011.

Dicamba drift on soybean is easily recognized by observable symptoms. This study measured the impact of drift on soybean occurring at two different soybean stages of development. The impact of drift on soybean yield may not be easily predicted by the level of injury observed without consideration for the stage of soybean development at application. The experiment was conducted near Ames, Iowa in 2009. The experimental design was randomized complete block with six replications. Soybean was planted at 76 cm row spacing on corn ground prepared by fall chisel plowing and spring field cultivation. Plots were 3 by 7.6 m. Dicamba drift was simulated by using reduced rates of diflufenzopyr & dicamba & isoxadifen-ethyl. Treatments included postemergence application rates of 0.002, 0.0002 and 0.00002 kg ai ha^{-1} applied to soybean at V3, and R1 stages (POST-V3, and POST-R1, respectively). All of the treatments included glyphosate applied alone (POST-V4) at 0.23 kg ae ha^{-1} for weed control. A control was included as a treatment that contained only the POST-V4 glyphosate application. Visual crop injury was evaluated at 7, 14, 21, 28 and 56 days after application (DAA) for POST-V3 and POST-R1 timings, respectively. Soybean yield was measured and adjusted to 13% moisture content. Soybean injury at 7 DAA, respective to V3 and R1 soybean application stages, demonstrated similar trends for herbicide application rate. However, at 14 DAA, injury was higher at all herbicide rates applied to V3 compared to R1 soybean (40, 10 and 5% compared to 26, 5 and 1%, respectively). By 21 DAA, injury was 42% compared to 31% for the 0.002 kg ai ha-1 rate applied to V3 and R1 soybean, respectively. The other herbicide rates did not produce differing soybean injury comparing V3 to R1 application timings when observed at 21, 28 and 56 DAA, respective to soybean stage at application. The trend for the highest herbicide application rate reversed at 28 DAA comparing 36% to 44% injury for V3 and R1 application timings, respectively. Injury was greater again for the 0.002 kg ai ha^{-1} applied to R1 soybean 56 DAA compared to V3 soybean with 39% compared to 23%, respectively. Soybean yield from the control was significantly greater than only the highest rate of diflufenzopyr & dicamba & isoxadifen-ethyl applied to both V3 and R1 soybeans. Yield was not significantly different comparing soybean stage at application for any of the herbicide rates.

HERBICIDE COMBINATIONS FOR WEED CONTROL IN GLYPHOSATE-RESISTANT ALFALFA. Alexander J. Lindsey*, Wesley J. Everman, Andrew J. Chomas and Steven A. Gower, Graduate Research Assistant, Assistant Professor and Research Technician, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824, Technical Development Representative, The Monsanto Company, St. Louis, MO 63101.

Current herbicides used for weed control in alfalfa, such as imazamox and imazethapyr, tend to control a narrow range of weeds. Glyphosate has been shown to control a broad spectrum of weeds, including many grasses and broadleaves. Additionally, the use of glyphosate allows greater flexibility in herbicide application timing. The objective of this study was to investigate the effect of eighteen herbicide treatments on alfalfa injury, growth, and dandelion control. Three treatments were applied 0 days after the initial cutting (DAC), fourteen treatments were applied 14 DAC, and one plot was left non-treated. Alfalfa stunting, chlorosis, and dandelion control were evaluated for the 0 DAC application timing at 14, and all treatments were evaluated 21, 28, and 35 DAC. Alfalfa yields were determined at 39 DAC and 70 DAC.

Applications of 2,4-DB alone, 2,4-DB plus glyphosate in the form of Roundup WeatherMAX® (WM), and 2,4-DB plus glyphosate in the form of Roundup Original Max® (OM) were made 0 DAC. Initial stunting 14 DAC caused by 2,4-DB, 2,4-DB + WM, and 2,4-DB + OM was 17.5, 18.5, and 20.5%, respectively. Dandelion control with 2,4-DB alone was 80% with the addition of glyphosate improving control to greater than 92%. Injury was observed 21 DAC following applications of 2,4-DB + WM, 2,4-DB + OM, imazethapyr + OM, 2,4-DB, and imazethapyr + WM caused stunting of 15, 15, 15, 11, and 11%, respectively. All other treatments stunted alfalfa less than 5% at 21 DAC. Imazethapyr + WM and imazethapyr + OM applications resulted in chlorosis of 16 and 13%, respectively, 21 DAC which was significantly higher than all other treatments. Dandelion control 21 DAC was highest with 2,4-DB, 2,4-DB + WM, 2,4-DB + OM, and 2,4-DB, 90, 95, and 100%, respectively. All other treatments exhibited 40% control or less at 21 DAC. Imazethapyr + OM, imazethapyr + WM, imazamox + WM, and clethodim + WM treated alfalfa displayed the most stunting 35 DAC with levels of 12, 10, 10, and 9%, respectively. Chlorosis 35 DAC was not significant with all treatments and was less than 3%. Dandelion control was highest with 2,4-DB + WM, 2,4-DB + OM, and imazamox + WM applications at 95, 90, and 88%, respectively. Pure alfalfa yield 39 DAC was greatest following clethodim, imazamox, non-treated, imazethapyr, sethoxydim, 2,4-DB + WM treatments with 2.3, 2.3, 2.3, 2.2, 2.2, and 2.2 ton/A, respectively. The imazamox + OM treatment yielded the lowest 39 DAC resulting in 1.5 ton/A.

Stunting and chlorosis were seen primarily in initial ratings with severity decreasing over time. Treatment impacts on alfalfa yield may have been exacerbated by cold July temperatures (average high of 75.4° F), resulting in reduced alfalfa growth. The yields at 70 DAC indicate alfalfa had recovered from initial injury due to herbicide application. Herbicide treatments examined in this experiment should be further evaluated to observe the effect of temperature and moisture on alfalfa injury and time of recovery.

LONG-TERM EFFECT OF WEED CONTROL AND CUTTING SYSTEM ON ROUNDUP READY ALFALFA. Andrew Chomas*, Timothy Dietz, James Kells, Wesley Everman and Richard Leep, Research Technician, Research Technician, Professor, Assistant Professor, Professor, Department of Crop and Soil Sciences Michigan State University, East Lansing MI 48864.

Weed control in alfalfa with glyphosate offers growers an alternative weed management system that may enhance alfalfa growth and persistence by providing a wider spectrum of weed control. Glyphosate is an effective herbicide for controlling weed species commonly found in established alfalfa stands. Field research was conducted from 2003-2009 to examine: 1) the effect of cutting systems on stand longevity, and 2) the effect of herbicide and management system on forage composition. The site was established on a Capac loam soil with a pH of 7.4 at the Michigan State University Agronomy Farm in East Lansing, Michigan. Glyphosate resistant alfalfa was planted at a rate of 18 lbs/A at a 6 inch spacing and managed according to commercial production practices in Michigan. Treatments were arranged in a split plot design with cutting frequency as the whole plot factor and herbicide treatment as the sub plot factor. Whole plots were managed either as an intensive management system or as a moderate management system based on number of cuttings in a season. Herbicide treatments consisted of no herbicide applied, glyphosate at 0.75 lb ae/A applied in the fall or spring of the year as needed, or hexazinone at 0.5 lb ai/A applied every other year in the spring. Cuttings were taken each year after establishment at 750 growing degree days base 41° F, starting March 1st with subsequent cuttings at 28 and 35 day intervals for the intensive and moderate management systems, respectively. Dry biomass yield, forage quality and alfalfa population data were collected. Weed and alfalfa dry biomass percentages were calculated from separation data. Forage yield was highest in the second production year and declined subsequently thereafter. The intensive management system resulted in higher yield than the moderate system in 2005-2006, whereas the moderate system resulted in the highest yield in 2009. There were no significant differences among weed control treatments for annual forage yield or weed control from 2004-2009. Stand persistence was not affected by cutting management system or weed control strategy. Very few weeds were present in any of the management plots in 2004. Following weed free establishment the use of herbicides removed weeds, but had no impact on alfalfa yield and did not increase the persistence of the alfalfa stand.

GRASS CONTROL WITH NICOSULFURON AND METSULFURON METHYL IN BERMUDAGRASS. Douglas E. Shoup, Assistant Professor, Department of Agronomy, Kansas State University, Chanute, KS 66720.

Limited options exist for grass control in bermudagrass pastures and meadows. The objective of this research was to evaluate johnsongrass (*Sorghum halepense*), downy brome (*Bromus tectorum*), and cheat (*Bromus secalinus*) control with nicosulfuron plus metsulfuron methyl in bermudagrass. Trials were conducted in 2008 and 2009 in southeast Kansas. Midsummer postemergence applications of nicosulfuron plus metsulfuron methyl provided greater than 85% control of Johnsongrass by one month after treatment (MAT) and 100% by 2 MAT. Dormant bermudagrass applications of nicosulfuron plus metsulfuron methyl controlled cheat between 62 and 87% by 1 MAT and 67 and 98% by 3 MAT. Downy brome control ranged from 60 to 87% 1 MAT and 72 to 96% control by 3 MAT with applications of nicosulfuron plus metsulfuron methyl. Glyphosate applications to dormant bermudagrass gave 100% control of all cool season grasses at both 1 and 3 MAT. No bermudagrass injury was detected in any herbicide treatments in either year.

PERFORMANCE ADVANTAGES OF FLAMING HOOD. Chris A. Bruening*, George Gogos, Santiago M. Ulloa, and Stevan Z. Knezevic. Graduate Student, Professor, University of Nebraska, Lincoln, NE, 68588; Graduate Research Assistant, Associate Professor, Haskell Agricultural Laboratory, University of Nebraska, Concord, NE 68728.

Utilizing a hood in flaming equipment has several advantages that can be readily observed in the field. A flaming hood can offer a higher quality and more consistent level of weed control by better utilizing the combustion heat, and when compared with a common open torch, a flaming hood can obtain the same level of weed control with less fuel. In addition, utilizing a hood in flaming equipment increases safety and enables weed control even under relatively windy conditions. These advantages in the field were observed in our previous studies. In order to gain a better understanding of the flaming hood characteristics, a laboratory study was performed in 2008. The objective was to collect a range of temperature measurements in order to describe how the new hood design compared to a common open torch in temperature distributions and maximums. Based on the results, the new hood design maintained higher maximum temperatures and a larger high temperature core over a significantly longer and wider path. For example, 80 cm away from the torch exit the hood maintained an almost uniform temperature of 800°C over the entire hood cross-sectional area, while the open torch had only a small region at 600°C and the perimeter temperatures had fallen below 400°C. (ggogos1@unl.edu)

RESPONSE OF SELECTED CROP AND WEED SPECIES TO PROPANE FLAMING AS INFLUENCED BY LEAF WATER CONTENT. Santiago M. Ulloa*, Avishek Datta, Stevan Z. Knezevic, Chris Bruening, George Gogos, and Timothy J. Arkebauer. Graduate Student, Post Doctoral Research Associate, and Associate Professor, Haskell Agricultural Laboratory, University of Nebraska, Concord, NE 68728; Graduate Student, and Professor, Mechanical Engineering, University of Nebraska, Lincoln, NE 68588; Professor, Department of Agronomy and Horticulture, University of Nebraska, Lincoln, NE 68583.

The relative water content (RWC) is the ratio of the water volume in a leaf to the maximum water volume at full turgor. To determine the influence of RWC in plant response to propane flaming, greenhouse experiments were conducted during spring of 2009. Two weeds (velvetleaf and green foxtail) and two crops (corn and soybean) were treated with four propane rates (0, 30, 60, and 90 kg/ha) at four different times of a day (6 am, 10 am, 2 pm, and 6 pm). The RWC was measured before treatment application. Flaming treatment was conducted utilizing a hand flamer with one VT-2-23C vapor phase burner positioned 20 cm above soil surface and angled at 30˚. The propane pressure was 18 PSI (100,000 BTU/hour) and the application speeds were 1, 2, and 3 mph. The plant responses evaluated were visual injury (1, 3, and 7 DAT) and fresh weight (7 DAT). All plant species had lower RWC during the afternoon, which made them more susceptible to flaming. For example, corn flamed with 90 kg/ha at 6 am had 48% injury 7 DAT compared to 70 % injury with the same propane rate at 6 pm. The same tendency was demonstrated by velvetleaf showing 71% injury when flamed with 90 kg/ha at 6 am and 98% injury 7 DAT when flamed at 6 pm. Similar trend occurred for green foxtail and soybean suggesting that RWC has an influence in plant response to flaming. Flaming could be more effective if done in the afternoon. santiago@huskers.unl.edu

A NOVEL WATER CONDITIONER FOR USE WITH GLYPHOSATE. Mark L. Bernards, Richard K. Zollinger, Bryan G. Young, R. Scott Tann, and Howard Stridde, Assistant Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE 68583-0915, Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58108, Professor, Department of Plant, Soil, and Agricultural Systems, Southern Illinois University-Carbondale, Carbondale, IL 62901, Business Manager-Agrochemicals Americas and Research Chemist, Huntsman, The Woodlands, TX 77380.

The hard-water cations calcium (Ca^{2+}), magnesium (Mg^{2+}), and iron (Fe^{3+}) reduce glyphosate efficacy by complexing with glyphosate to form salts that are not readily absorbed by plants. The antagonism caused by hard-water cations may be overcome by increasing the glyphosate concentration relative to the cation content, or by adding a water conditioner to the spray solution. Granular ammonium sulfate (AMS) is the product most commonly recommended as a water conditioner because it is highly effective and relatively inexpensive. However, many pesticide applicators choose to use liquid AMS replacement products instead of granular AMS because liquid products are more convenient to load into the tank. Most of these replacement products contain some AMS, but when used at the marketed use rates (0.25-1.0%) do not provide the same level of water conditioning as granular AMS at its recommended use rate (1-2% w/v). The chemical U8784 was identified as a potential water conditioner. The objective of this research was to compare U8784 to AMS for efficacy in overcoming the Ca^{2+} antagonism of glyphosate. In an initial screening study, U8784 increased glyphosate activity in 500 mg Ca^{2+}/L water similarly to AMS (2% w/v) on sunflower, and increased activity more than AMS on wheat. Formulating U8784 with a surfactant further enhanced glyphosate's activity on wheat, but reduced activity on sunflower. In a second study, U8784 overcame a 1000 mg Ca^{2+}/L water antagonism on sunflower and wheat, but not on green foxtail. Dose response studies were conducted to compare the rate of U8784 to rate of AMS. The formulation of U8784 had a low concentration of the active molecule, hence, use rates ranged from 0 to 32% (v/v). AMS rates ranged from 0 to 2% (w/v). Glyphosate activity increased on sunflower, velvetleaf and green foxtail in 1000 mg Ca^{2+}/L water as U8784 and AMS rates increased, and the curves were similar for both products. We believe that U8784 has the potential to be developed as a novel water conditioner for glyphosate.

DOCTOR OF PLANT HEALTH: A NEW INTER-DISCIPLINARY PROGRAM FOR PLANT HEALTH PRACTITIONERS. Gary Hein, John Lindquist, Mark Bernards, and Lowell Sandell; Director, DPH Program, Associate Professor, Assistant Professor and Extension Educator, Agronomy and Horticulture Department, University of Nebraska – Lincoln, Lincoln, NE 68583.

Individuals with integrated knowledge and management skills are needed to deal with the complex and frequently interacting challenges to plant health. To meet this demand for plant professionals, the Doctor of Plant Health (DPH) program is now being offered by the University of Nebraska-Lincoln, Institute of Agriculture and Natural Resources. The program is the second of its kind in the United States. The DPH degree is for students interested in a successful career as a plant health practitioner to address these complex needs. In the DPH program, students will be trained broadly across multiple disciplines (entomology, plant pathology, plant science, soil science and weed science). In addition to this broad training, students will be required to undertake extensive internships where they will learn to integrate their broad knowledge to address plant management issues. In these experiential learning opportunities, emphasis will be on the development and implementation of plant and pest management systems and on the diagnoses and management of all biotic and abiotic plant health challenges. The curriculum is broad-based, but students may emphasize crop or plant areas such as field crops, ornamentals, specialty crops, turf grasses, landscapes, or other professional interest areas, including regulatory or business management. Students completing the program will have career opportunities in industry, crop consulting, government, extension, and other private practice. Industry and government, both local and national, have indicated a desire to hire graduates with this type of training.

UTILIZATION OF SEQUENTIAL HERBICIDE APPLICATIONS AND HERBICIDE TANKMIX COMPONENTS TO IMPROVE GLYPHOSATE EFFICACY. Lisa M. Behnken*, Ryan P. Miller, Fritz R. Breitenbach, and Jeffery L. Gunsolus, Extension Professor, University of Minnesota, Rochester Regional Center, Rochester, MN 55904-4915, Assistant Extension Professor, University of Minnesota, Rochester Regional Center, Rochester, MN 55904-4915, Extension Professor, University of Minnesota, Rochester Regional Center, Rochester, MN 55904-4915, Associate Extension Professor, University of Minnesota, Rochester Regional Center, Rochester, MN 55904-4915, and Professor, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108-6026.

Field research was conducted at Rochester, MN in 2007, 2008 and 2009 to determine which tank mix components and sequential applications improved glyphosate efficacy. A randomized complete block design with four replications was used. Soybean variety 'Dairyland DSR 199' was planted on May 17, 2007, soybean variety 'Dairyland DSR 1302' was planted on May 23, 2008 and soybean variety 'Asgrow 2108' was planted on May 19, 2009. Soybeans were planted at 3.8 cm deep in 76 cm rows at a rate of 370,500 seeds ha^{-1}. All herbicide applications were made with a tractor-mounted sprayer delivering 187 l ha^{-1} at 221 kpa using 11002 flat fan nozzles. Treatments were made according to label instructions and adequate rainfall was received after each treatment date. A reduced rate of 420 g ae glyphosate ha^{-1} was used to better determine the effect of corresponding tank mix and sequential treatments.

In 2007 preemergence treatments included: flumioxazin + cloransulam-methyl at 89 + 29.4 g ai ha^{-1} (Gangster); flumioxazin at 89 g ai ha^{-1} (Valor); sulfentrazone + cloransulam-methyl at 130 + 16.6 g ai ha^{-1} (Sonic); s-metolachlor + fomesafen at 1065 + 233 g ai ha^{-1} (Prefix), and sulfentrazone + metribuzin at 126 + 189 g ai ha^{-1} (Authority MTZ). In 2008, several preemergence treatments were added: sulfentrazone + imazethapyr at 346.6 + 70.4 g ai ha^{-1} (Authority Assist), and chlorimuron-ethyl + flumioxazin + thifensulfuron-methyl at 5.6, 71, and 17.25 g ai ha^{-1} (Enlite). Pendimethalin at 1600 g ai ha^{-1} (Prowl H_2O) was applied preplant incorporated.

Postemergence treatments were 420 g ae glyphosate ha^{-1} alone or tank mixed with one of the following components: fomesafen at 197 g ai ha^{-1} (Flexstar); lactofen at 105 g ai ha^{-1} (Cobra); flumiclorac-pentyl-ester at 30 g ai ha^{-1} (Resource); cloransulam-methyl at 19.4 g ai ha^{-1} (FirstRate); chlorimuron-ethyl at 4.37 g ai ha^{-1} (Classic); chlorimuron-ethyl at 6.63 g ai ha^{-1} (Classic); chlorimuron-ethyl + thifensulfuron-methyl at 5.7 + 1.8 g ai ha^{-1} (Synchrony XP), thifensulfuron-methyl at 17.4 g ai ha^{-1} (Harmony GT), imazethapyr at 70 g ai ha^{-1} (Pursuit). In 2008, fluthiacet-methyl at 3.2 g ai ha^{-1} (Cadet) was added as a tank mix treatment.

In 2009, preemergence treatment modifications included: saflufenacil + imazethapyr at 25 + 70 g ai ha^{-1} (Optill), sulfentrazone + cloransulam-methyl at 195 & 25 g ai ha^{-1} (Sonic), s-metolachlor + fomesafen at 1218 + 267 g ai ha^{-1} (Prefix), and s-metolachlor + metribuzin at 1326 + 316 g ai ha^{-1} (Boundary). Modifications to postemergence treatments were 420 g ae glyphosate ha^{-1} tank mixed with the following: fomesafen at 197 g ai ha^{-1} (Flexstar) + thifensulfron-methyl at 4.38 g ai ha^{-1} (Harmony GT), chlorimuron-ethyl at 5.8 g ai ha^{-1} (Classic), thifensulfron-methyl at 4.38 g ai ha^{-1} (Harmony GT), pendimethalin at 1600 g ai ha^{-1} (Prowl H_2O) applied preplant incorporated followed by postemergence application of glyphosate + fomesafen at 197 g ai ha^{-1}. All preemergence treatments were followed by a postemergence treatment of glyphosate.

Weeds were visually rated for percent control, soybean was evaluated for injury and plots were machine harvested with yields calculated and adjusted to 13.0% moisture. Sequential treatments that included a preemergence application tended to have greater grain yields and better weed control than glyphosate with the various tank mix treatments. In 2009, all of the tank mix partners caused soybean injury with several resulting in substantial injury to soybean, 13-54%.

COMPARISON OF PREEMERGENCE AND POSTEMERGENCE HERBICIDE PROGRAMS UTILIZING BEST MANAGEMENT PRACTICE RATES OF ATRAZINE OR ATRAZINE REPLACEMENTS IN FIELD CORN AT ROCHESTER, MINNESOTA. Lisa M. Behnken*, Ryan P. Miller, Fritz R. Breitenbach, and Jeffery L. Gunsolus, Extension Professor, University of Minnesota, Rochester Regional Office, Rochester, MN 55904-4915, Assistant Extension Professor, University of Minnesota, Rochester Regional Office, Rochester, MN 55904-4915, Associate Extension Professor, University of Minnesota, Rochester Regional Office, Rochester, MN 55904-4915, and Professor, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108-6026.

Field research was conducted at Rochester, MN in 2007, 2008, and 2009 to 1) evaluate weed control of herbicide programs with and without atrazine applied at BMP rates, 2) evaluate performance of herbicides used as replacements for atrazine and 3) evaluate crop safety of potential replacements in field corn in southeastern Minnesota. The research site was a Lawler loam series with a pH of 7.0, 6.7, and 6.8, soil test P of 16, 22, and 37 ppm and soil test K of 160, 126, and 115 ppm, respectively in 2007, 2008 and 2009. The corn hybrid, 'Pioneer 38H65', was planted on April 27, 2007, the hybrid, 'DeKalb DKC50-19', was planted on May 9, 2008, and the hybrid ' Pioneer 35F44' was planted on May 8, 2009. They were planted at a depth of 3.8 cm in 76-cm rows at 79,073 seeds ha^{-1}. A randomized complete block design with four replications was used. Preemergence and postemergence treatments were applied with a tractor-mounted sprayer delivering 187 l ha^{-1} at 221 kpa using 11002 flat fan nozzles. A one-half label use rate of s-metolachlor at 1.07 kg ai ha^{-1} was applied preemergence to the entire plot area.

In 2007, six postemergence treatments were evaluated, mesotrione at 0.105 kg ai ha^{-1}, mesotrione at 0.105 kg ai ha^{-1} + atrazine at 0.56 kg ai ha^{-1}, flumetsulam & clopyralid at 0.039 & 0.105 kg ai ha^{-1}, flumetsulam & clopyralid at 0.039 & 0.105 kg ai ha^{-1} + atrazine at 0.56 kg ai ha^{-1}, dicamba at 0.56 kg ai ha^{-1} and dicamba at 0.56 kg ai ha^{-1} + atrazine at 0.56 kg ai ha^{-1}. In 2008, four additional postemergence treatments were evaluated, mesotrione at 0.105 kg ai ha^{-1} + bromoxynil at 0.105 kg ai ha^{-1}, mesotrione at 0.105 kg ai ha^{-1} + dicamba at 0.14 kg ai ha^{-1}, flumetsulam & clopyralid at 0.039 & 0.105 kg ai ha^{-1} + mesotrione at 0.035 kg ai ha^{-1}, and dicamba at 0.56 kg ai ha^{-1} + mesotrione at 0.035 kg ai ha^{-1}. Weed control evaluations were conducted for giant ragweed, common lambsquarters and common waterhemp. Plots were also evaluated for corn injury and corn grain yield.

In 2009, thirteen treatements were evaluated. Four preemergence programs included s-metolachlor at 0.94 kg ai ha^{-1} + mesotrione at 0.092 kg ai ha^{-1} / nicosulfuron at 0.035 kg ai ha^{-1}, s-metolachlor at 0.94 kg ai ha^{-1} + mesotrione at 0.094 kg ai ha^{-1} + atrazine at 0.35 kg ai ha^{-1}/ nicosulfuron at 0.035 kg ai ha^{-1}, acetochlor at 0.92 kg ai ha^{-1} + flumetsulam at 0.29 kg ai ha^{-1} + clopyralid at 0.093 kg ai ha^{-1} and acetachlor at 0.92 kg ai ha^{-1}+ flumetsulam at 0.29 kg ai ha^{-1}+ clopyralid at 0.093 kg ai ha^{-1} + atrazine at 0.56 kg ai ha^{-1}. Nine postemergence programs included glufosinate at 0.47 kg ai ha^{-1}, glufosinate at 0.47 kg ai ha^{-1} + atrazine at 0.56 kg ai ha^{-1}, glufosinate at 0.47 kg ai ha^{-1} + bromoxynil at 0.105 kg ai ha^{-1}, thiencarbazone-methyl at 0.015 kg ai ha^{-1} + tembotrione at 0.076 kg ai ha^{-1}, thiencarbazone-methyl at 0.015 kg ai ha^{-1} + tembotrione at 0.076 kg ai ha^{-1} + atrazine at 0.56 kg ai ha^{-1}, thiencarbazone-methyl at 0.015 kg ai ha^{-1} + tembotrione at 0.076 kg ai ha^{-1} + bromoxynil at 0.105 kg ai ha^{-1}, s-metolachlor at 1.05 kg ai ha^{-1} + glyphosate at 1.05

kg ai ha^{-1} + mesotrione at 0.105 kg ai ha^{-1} , s-metolachlor at 1.05 kg ai ha^{-1} + glyphosate at 1.05 kg ai ha^{-1} + mesotrione at 0.105 kg ai ha^{-1}+ atrazine at 0.56 kg ai ha^{-1}, and s-metolachlor at 1.05 kg ai ha^{-1}+ glyphosate at 1.05 kg ai ha^{-1} + mesotrione at 0.105 kg ai ha^{-1} + bromoxynil at 0.105 kg ai ha^{-1}. Weeds evaluated in 2009 were common lambsquarters, common waterhemp, velvetleaf and woolly cupgrass. Plots were also evaluated for corn injury and corn grain yield.

In 2007 and 2008 giant ragweed control was improved when treatments included atrazine. In 2008, mesotrione + either bromoxynil or dicamba provided similar giant ragweed control as mesotrione + atrazine. However, mesotrione + bromoxynil resulted in 20% injury to corn. Flumetsulam & clopyralid + atrazine or mesotrione at a reduced rate, 0.035 kg ai ha^{-1}, provided significantly greater giant ragweed control than flumetsulam & clopyralid applied alone. Flumetsulam & clopyralid + mesotrione provided greater control than flumetsulam & clopyralid + atrazine. In 2008, dicamba + mesotrione provided weed control equivalent to dicamba + atrazine. In 2007 and 2008, common waterhemp and common lambsquarters control were similar for mesotrione and mesotrione + atrazine. Flumetsulam & clopyralid + atrazine and dicamba + atrazine provided greater control of common waterhemp and common lambsquarters control in 2007. In 2008, common waterhemp control was improved significantly with the addition of the BMP rate of atrazine or mesotrione to flumetsulam & clopyralid as compared to flumetsulam & clopyralid alone. Also, common waterhemp control with flumetsulam & clopyralid + mesotrione at 0.035 kg ai ha-1 was significantly greater than with atrazine. Corn grain yields were greater for both mesotrione + atrazine and flumetsulam & clopyralid + atrazine when compared to their non-atrazine partners in 2007. Due to plot variability in 2008, corn yields were not significantly different at the $P \leq 0.10$.

In 2009, weed control was similar for herbicide programs with and without atrazine or bromoxynil for common lamsquarters, common waterhemp, and velvetleaf. Woolly cupgrass control was reduced when either atrazine or bromoxynil was added to thiencarbazone-ethyl + tembotrione. With this group of herbicide comparisons, corn yield with and without the BMP rate of atrazine was similar. Corn yield for all comparisons with and without bromixynil was also similar. BMP rates of atrazine can improve the effectiveness of mesotrione, flumetsulam & clopyralid and dicamba on certain weeds and increase grain yields. The data from 2008 would indicate that bromoxynil, mesotrione, and dicamba may be potential replacements for atrazine. The data from 2009 suggest that herbicide programs performed equally well, with and without atrazine on the weed species evaluated in this trial. However, more research is necessary with this herbicide comparison, specifically on giant ragweed control.

CONVENIENCE AND SIMPLICITY? AN ILLUSION AND A DETRIMENT TO INTEGRATED WEED MANAGEMENT. Mike Owen, Chris Boerboom and Christy Sprague, Professor, Department of Agronomy, Iowa State University, Ames, IA 50011, Professor, Department of Agronomy, University of Wisconsin, Madison, WI 53706, Associate Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824-0000.

Two of the main benefits growers ascribe to crop production systems based on herbicide-resistant crops (HRC) are the convenience and simplicity of weed control. However, these presumptions of convenience and simplicity are not valid and have negative environmental, ecological and economical implications. Importantly, the inclusion of integrated weed management (IWM) philosophy and resulting diversification of weed management tactics resolves these issues. The one aspect that likely could gain traction with growers is the improved economics of IWM; using a diverse weed management program improves profitability compared to single herbicide tactics most often used in HRCs. Interestingly, growers and agchem professionals are aware of negative ecological implication of the current systems but apparently have determined that the presumed convenience and simplicity of the systems override the negative aspects of the current practices. An Iowa survey of 6588 growers indicated that 26% of the growers surveyed reported that HRC fields are becoming more weedy and 45% reported that increased glyphosate rates and frequency of applications are now required for weed control. The same questions were answered by 568 agchem professionals who reported a higher concern for weedy fields (40%) and more glyphosate needed (57%). Given the rapid evolution of glyphosate-resistant weeds in cotton and soybean production systems based on HRCs, it is difficult to understand why growers continue to base weed control on a single herbicide tactic. The adoption of IWM can resolve the negative aspects of the current HRC systems but has, to date, not been widely accepted by growers.

BENCHMARK STUDY: PERSPECTIVES ON GLYPHOSATE-RESISTANT CROPS AND THE SUSTAINABILITY OF CHEMICAL WEED MANAGEMENT. Micheal D. K. Owen, Bryan G. Young, David R. Shaw, Robert G. Wilson, David L. Jordan, Stephen C. Weller and Philip Dixon, Professor, Agronomy Department, Iowa State University, Ames, IA 50011, Professor Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901, Professor , Plant and Soil Science Department, Mississippi State University, Mississippi State, MS 39762, Professor, Department of Agronomy and Horticulture, University of Nebraska, Scottsbluff, NE 69361-4939, Professor, Department of Crop Science, North Carolina State University, Raleigh, NC 27695-7620, Professor, Department of Horticulture, Purdue University, West Lafayette, IN 47907-2010, Professor, Department of Statistics, Iowa State University, Ames, IA 50011.

A six-state field-scale project was initiated to study methods that may help glyphosate-resistant (GR) systems remain sustainable in terms of grower economics and the evolution of weed resistance. The four-year study was initiated following a farmer survey on weed management practices and their views on GR weeds and management. The findings included: 1) 30% of farmers thought GR weeds were or would become a serious problem; 2) few farmers thought tillage and/or using a non-GR crop in rotation would help prevent or manage GR weed evolution and 3) most farmers underestimated the role of herbicide selection pressure on the evolution of herbicide resistance. These results suggest major challenges facing agriculture and the weed science communities with regard to establishing sustainable systems within the GR-crop agroecosystems. Paramount is the need to develop and communicate clear science-based management recommendations that minimizes current rhetoric and convinces farmers to change long-held bias about weed control thus reducing the evolution of weed populations resistant to herbicides. Without a proactive and integrated approach to manage weeds in GR crops, the continued and wide-spread evolution of GR weeds is inevitable. This will be problematic in all crop systems and endanger the economics of GR technology which dominates current agriculture globally. Furthermore, lack of action on the part of the weed science communities increases the likelihood of regulatory intervention. Given present systems where alternatives to chemical weed control are essentially impractical, anything that compromises GR technology will significantly damage global agricultural productivity if effective solutions are not identified.

WATERHEMP GENOMICS FOR HERBICIDE RESISTANCE RESEARCH. Chance W. Riggins, Patrick J. Tranel, Yanhui Peng, and C. Neal Stewart Jr., Postdoctoral Research Associate and Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801, Postdoctoral Research Associate and Professor, Department of Plant Sciences, University of Tennessee, Knoxville, TN 37996.

Genomic resources for waterhemp have been expanded as a result of Roche 454 pyrosequencing technology. Whole genome and transcriptome pyrosequencing produced 158,015 (43 Mbp) and 483,225 (114.8 Mbp) raw reads, respectively, which have enabled us to develop new marker-based assays to address important questions related to the genetics, molecular mechanisms, and spread of herbicide resistance in waterhemp. For example, of the 44,469 assembled transcriptome reads (contigs + singletons), forty-nine percent displayed highly significant similarities to *Arabidopsis* proteins and were subsequently grouped into gene ontology categories. These initial hits combined with further BLAST searches against custom databases have helped us identify and obtain preliminary sequence data for all of the major target-site genes for which waterhemp has documented resistance. Moreover, sequence data for two other targets where resistance has not yet been reported in any plant were also investigated in waterhemp and six related weedy *Amaranthus* species. These preliminary experimental results demonstrate the enormous value of 454 sequencing for gene discovery and mutation detection in a major weed species and its relatives. Additional examples of current and potential applications of this valuable resource are also highlighted.

INTRODUCING QUAD-STACK WATERHEMP: POPULATIONS CONTAINING INDIVIDUALS RESISTANT TO FOUR HERBICIDE MODES OF ACTION. Michael S. Bell, Patrick J. Tranel, and Aaron G. Hager, Graduate Research Assistant, Professor and Associate Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

A waterhemp population from western Illinois was reported resistant to glyphosate. Results from on-site field trials in 2008 indicated the population contained other herbicide resistances as well. Thus, seeds were collected from female waterhemp plants for greenhouse studies. By treating greenhouse-grown plants with atrazine, lactofen, imazamox, or glyphosate, it was confirmed that the population contains resistance to each of these four herbicides. Further experiments were conducted to test for individual plants with multiple resistance. To reduce potential antagonism among herbicides, some of the herbicides were applied sequentially. In one run, seedlings were treated with an atrazine-imazamox tank mix. Survivors were then treated with a glyphosate-lactofen tank mix, and four-way resistant individuals were identified. In a second run, imazethapyr was applied to the soil soon after sowing the seeds, and emerged seedlings were then treated with atrazine at the four-leaf growth stage. Survivors of the atrazine treatment were then sprayed with a tank mix of glyphosate and lactofen. Again, four-way resistant individuals were identified.

In a parallel study, an F_2 waterhemp population was derived from a cross between a parental line that was fixed for resistance to atrazine, ALS-inhibitors, and PPO-inhibiting herbicides, and a parental line that demonstrated near-uniform resistance to glyphosate. Individuals in this F_2 population were screened for resistance to each of four herbicides, and all four types of resistance were confirmed to be present in the population. This F_2 population was then screened for four-way resistant individuals. Imazethapyr was applied to the soil soon after the seeds were sown, and emerged seedlings were sprayed with atrazine at the four-leaf stage. Survivors of this treatment were then sprayed with a glyphosate-lactofen tank mix and survivors were identified. This population was also used to test for any possible linkage between the resistance genes by using molecular markers as well as phenotypic data from sequential herbicide treatments.

Waterhemp's obligate outcrossing provides an efficient mechanism for combining different herbicide resistances within a single individual. As evidence for this, a field-evolved biotype possessing four different herbicide resistances has now been confirmed. Greenhouse crossing experiments suggested there are no obstacles to combining the four different resistances. Thus, continued evolution of multiple resistant waterhemp populations is expected.

ABSORPTION AND TRANSLOCATION OF GLYPHOSATE AND CHLORIMURON IN A TANK-MIX. Rachel K. Bethke, Wesley J. Everman, Donald Penner. Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI.

Crops with traits for resistance to multiple herbicides provide the opportunity for farmers to control herbicide resistant weeds through tank-mixing. Past research has shown that unexpected interactions can occur when herbicides of different chemistries are mixed. Combinations of glyphosate and chlorimuron may cause unexpected interactions; a fast acting herbicide may reduce the absorption and translocation of a slow acting herbicide. The objective of this study was to evaluate the absorption and translocation of glyphosate and chlorimuron applied alone, and in combination on two annual weeds prevalent in Michigan, common lambsquarters and giant foxtail. Preliminary studies have shown that a negative interaction (antagonism) occurs when glyphosate and chlorimuron are applied together at a wide range of rates. ^{14}C-chlorimuron and ^{14}C -glyphosate were used to determine the cause of visually observable interaction. The absorption data showed that combining low rates of glyphosate with chlorimuron increased chlorimuron absorption. Similarly, low levels of chlorimuron increased glyphosate absorption. Current research is focused on explaining this anomaly.

CHLOROPHYLL FLUORESCENCE TO ASSESS GLYPHOSATE RESPONSE IN HERBICIDE RESISTANT GIANT RAGWEED (*AMBROSIA TRIFIDA* L.) Renae R. Robertson, Burkhard Schulz, and Stephen C. Weller, Graduate Research Assistant, Assistant Professor, Professor, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907.

The annual giant ragweed (*Ambrosia trifida* L.) persists in disturbed areas and croplands. Farmers often use glyphosate for weed control of giant ragweed. Glyphosate is the most widely used herbicide worldwide and destroys weeds by inhibiting EPSP synthase, the key enzyme of the shikimate pathway. Repeated use of glyphosate allowed the isolation of glyphosate resistant (R) giant ragweed plants in Indiana. This study investigated quantifiable parameters of responses to glyphosate in resistant (R) and sensitive (S) populations of giant ragweed. Previously, we have observed a noticeable difference in temporal and phenotypical response reactions to glyphosate applications in R versus S populations of giant ragweed. In order to study the basis of these response differences, we used an Imaging-PAM fluorometer (Walz GmbH) to measure photosynthetic activity in leaves of R and S giant ragweed populations after foliar treatment with glyphosate. Our technique involved treating R and S giant ragweed leaves with glyphosate, and then removing the leaf at a given time point to measure photosynthetic inhibition. The Image-PAM fluorometer detected significantly reduced photosynthetic activity measured as an increase in fluorescence within 6 hours of glyphosate treatment in the R leaf. After 24 hours, this reduction in fluorescence was widespread over the entire leaf surface. The treated S plant leaf showed only limited leaf injury (at 6 hours) and much less reduced photosynthetic activity even 24 hours after herbicide treatment. Data suggest a response mechanism in R plants that results in faster injury than would be expected merely by inhibition of EPSP synthase, the target enzyme of glyphosate. The injury response in the R population resembles a hypersensitive-like response commonly seen in plants after pathogen attack. Further studies are investigating the possible mechanisms of the hypersensitive-like response observed in R plants and what role it plays in the ability of R plants to survive a glyphosate concentration that kills S plants.

IN VITRO ASSAY FOR ASSESSMENT OF GLYPHOSATE RESPONSE USING A LEAF DISK SYSTEM. Renae R. Robertson, Burkhard Schulz, and Stephen C. Weller, Graduate Research Assistant, Assistant Professor, Professor, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907.

In recent years glyphosate use has increased significantly due to the widespread culture of glyphosate resistant agronomic crops. Increased glyphosate use has resulted in selection of 16 glyphosate resistant weed biotypes worldwide. This study was designed to determine the optimal conditions for developing a non-destructive bioassay for identifying glyphosate resistance in weeds. Giant ragweed (*Ambrosia trifida* L.) was used in this in *vitro* assay which was performed by floating leaf disks from sensitive (S) and resistant (R) populations in 24-well plates on a table shaker. Each plate was placed under either dark, low light, or high light intensities to evaluate an ideal light condition to observe an effect. Leaf disks (13 mm) from either young or mature leaves were evaluated for response. Disks were floated in four water solution treatments: 0, 4, and 8% sucrose and a combination of aromatic amino acids (phenylalanine, tyrosine, and tryptophan) with and without glyphosate. After 48 hours of exposure to the various solutions, leaf disks were weighed and chlorophyll extracted. Total chlorophyll content after treatment, was the best indication of differences in response between resistant and sensitive populations. Tissue from mature leaves floated in 0% solution under high light conditions in the presence of glyphosate resulted in the best glyphosate response. Our results show that a non-destructive *in vitro* leaf disk assay is an effective technique to determine differences in plant response to glyphosate between R and S populations of giant ragweed.

RESPONSE OF HORSEWEED POPULATIONS TO FOUR DIFFERENT GROWTH REGULATOR HERBICIDES. Ryan S. Henry, Greg R. Kruger, Vince M. Davis, Stephen C. Weller, William G. Johnson, Graduate Research Assistant, Graduate Research Assistant, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907, Assistant Professor, Department of Crop Science, University of Illinois, Urbana, IL 61801, Professor, Department of Horticulture and Landscape Architecture, Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Dicamba and 2,4-D are commonly used growth regulator herbicides to control glyphosate-resistant horseweed (*Conyza canadensis*). These herbicides are currently limited to application before crops are planted. However, 2,4-D and dicamba tolerant corn and soybean are scheduled to be released in the near future, and this will increase the use of these herbicides for mid-season weed control. A greenhouse dose response study was conducted to evaluate the effectiveness of 2,4-D ester, 2,4-DB, diglycolamine salt of dicamba, and dimethylamine salt of dicamba on four Indiana horseweed populations. One population displayed two-fold higher levels of tolerance to 2,4-D ester. Two populations displayed a three-fold and four-fold higher tolerance to diglycolamine salt of dicamba. Four times the labeled rate of 2,4-DB was needed to achieve 90% control. Diglycolamine salt of dicamba provided the highest level of control of the four herbicides tested. The results of this study indicate these growth regulator herbicides, except 2,4-DB, are effective options for controlling glyphosate-resistant horseweed.

EFFICACY OF FLUMIOXAZIN AS AFFECTED BY SOIL ORGANIC MATTER, CLAY CONTENT AND SOIL pH. Calvin F. Glaspie*, Wesley J. Everman, John Pawlak and Andrew J. Chomas, Graduate Student, Assistant Professor, Research Assistant, Michigan State University, Department of Crop and Soil Sciences, 478 Plant and Soil Science, East Lansing, MI 48824, Product Development Manager, Valent U.S.A., P.O. Box 8025, Walnut Creek, CA 94596.

Flumioxazin is a protoporphyrinogen oxidase inhibiting broadleaf herbicide used for control of weeds in several cropping systems including cotton, peanut, soybean, sugarcane and sweet potato. In most cropping systems flumioxazin is applied preemergence for early season weed control. Previous studies have been conducted on the persistence of this compound to understand its environmental fate in the soil. These studies however, have not focused on the impact soil constituents have on flumioxazin's residual weed control. To understand the effect soil amendments and pH have on residual weed control of flumioxazin, a replicated greenhouse experiment was conducted in 2008 and 2009 at Michigan State University. The statistical design was a factorial arrangement of treatments with soil amendment percentage factored by herbicide treatment being non-treated or treated with 71 g ai/ha of flumioxazin. Clay soils used in the study were 0, 10, 20, 30, 40, 50, 60 and 70% clay by mass created by adding kaolin clay to sand. Organic soils used in the study were 0, 0.5, 1, 2, 4, 8, 16, and 32% organic matter by mass created by adding muck soil (88% organic material) to sand. Soils with varying pHs were created by acidifying (H_3PO_4) or neutralizing (NaOH) a control soil (pH of 4.56) to a pH of 4, 5, 6, 7, 8 and 9. Seeds of velvetleaf (Abutilon theophrasti), barnyardgrass (Echinochloa crus-galli), and redroot pigweed (Amaranthus retroflexus) were incorporated into the top 1.27 cm of each soil at a density of 100 seeds per pot. Emerged plants were counted and removed in both treated and not-treated pots 2 weeks after planting, and each following week for 6 weeks. Efficacy of flumioxazin was evaluated by calculating percent emergence of weeds in treated soils compared to emergence of weeds in non-treated soils. Emergence of weeds varied by soil alteration and followed general trends as soil parameters increased. Weed emergence was greatest 2 weeks after planting and decreased each week after. Efficacy of flumioxazin was not affected by clay content or soil pH, but decreased as organic matter content increased. Further work is still needed to evaluate each soil factor's role in flumioxazins control of weeds.
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COMMON LAMBSQUARTERS RESPONSE TO GLYPHOSATE ACROSS ENVIRONMENTS. Evan C. Sivesind[1], Chris M. Boerboom[2], David E. Stoltenberg[2], and John M. Gaska[3], [1]Research Associate, [2]Professor, and [3]Outreach Specialist, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

Glyphosate use has increased dramatically as conservation-tillage practices and the adoption of glyphosate-resistant crops have become widespread. Common lambsquarters is a major problem weed of soybean and corn cropping systems in the upper Midwest. It is highly competitive and control with glyphosate can be inconsistent. We conducted a series of experiments to explore factors that may contribute to this inconsistent control.

Field research was conducted in 2006 and 2007 to determine the response of common lambsquarters to glyphosate under a wide-range of environmental conditions. Glyphosate was applied at 0.84 kg ae ha^{-1} plus 1 kg ha^{-1} ammonium sulfate to 10-cm tall plants on 18 dates in each year and to 20-cm tall plants on 18 dates in 2007. Control was assessed as visual injury relative to nontreated plants 28 days after herbicide treatment. In 2006, control of 10-cm tall plants did not differ among17 of 18 dates, and was 99% or greater. However, control was 0% on one date, and was attributed to 1 mm of rainfall within 1.5 hr of application. In 2007, control of 10-cm tall plants was less on three dates (93, 83, and 71%) relative to other dates. Similarly, control of 20-cm tall plants was less on two dates (88 and 81%) relative to all other dates. Regression analysis did not show any consistent relationships between environmental parameters (relative humidity, temperature at time of treatment, minimum and maximum temperature pre- and post-treatment) and visual injury ratings even though notable variation of environmental conditions existed. For example, the minimum air temperature 24 hr before and after application ranged from 4 to 24 and 0 to 24 C, respectively. The maximum air temperature 24 hr before and after application ranged from 18 to 32 and 12 to 33 C, respectively.

To investigate the effects of growth stage on common lambsquarters response to glyphosate, dose-response experiments were conducted at four sites in 2004 and 2005. Glyphosate was applied at doses ranging from 0.1 to 3.2 kg ha^{-1} to 10- and 20-cm tall plants. Above-ground dry mass (expressed as percentage of nontreated plants) was regressed over dose using a four parameter logistic equation. Doses that reduced mass by 50% (effective dose, ED_{50}) ranged from 0.06 to 0.17 kg ha^{-1} for 10-cm tall plants and 0.05 to 0.49 kg ha^{-1} for 20-cm tall plants across site-years. ED_{50} values were not affected by plant size in two site-years, but were 1.9 to 2.8 times greater for 20- than 10-cm tall plants in two other site-years. We also investigated the effect of rainfall on common lambsquarters response to glyphosate. In field experiments conducted in 2005 and 2006, glyphosate was applied at 0.84 kg ha^{-1} plus 1 kg ha^{-1} ammonium sulfate to common lambsquarters, followed by simulated rainfall 0.5, 1.0, 2.0 and 4.0 hr after treatment. Control was assessed as visual injury as described above. In each year, control increased with greater time between glyphosate application and rainfall.

Glyphosate was highly effective in controlling common lambsquarters under a wide range of environmental conditions in this study with a few exceptions. We were not able to identify environmental parameters that reduced efficacy in all cases. Rainfall following application and common lambsquarters stage of growth may be important contributing factors in certain instances of relatively low glyphosate efficacy. Subtle combinations of biotic and abiotic factors may be responsible for some instances of reduced glyphosate efficacy on common lambsquarters.

PREEMERGENCE WEED CONTROL IN ONION WITH PENDIMETHALIN, FLUMIOXAZIN, ETHOFUMESATE, DIMETHENAMID-P, S-METOLACHLOR, ACETOCHLOR, AND PROPACHLOR. Chad M. Herrmann and Bernard H. Zandstra, Graduate Assistant and Professor, Michigan State University, East Lansing, MI 48824.

The majority of Michigan onion production occurs on muck soils, and onions are direct-seeded in April and harvested in September. The long growing season and poor competitive ability of onion require season-long weed control efforts, including several preemergence and postemergence herbicide applications and potential handweeding. Several preemergence herbicides have been labeled for use in onion recently, including flumioxazin, ethofumesate, dimethenamid-p, and s-metolachlor. A new, water-soluble formulation of pendimethalin increases crop safety. Two unlabeled chloroacetamides, acetochlor and propachlor, have potential to provide good weed suppression.

Field experiments were conducted in 2008 and 2009 to evaluate the weed control efficacy and crop tolerance of these preemergence herbicides on muck soils. Plots were treated sequentially, and the first application (PRE) was made to bare soil after seeding but prior to onion emergence. The second and third applications were made at the 2 leaf stage (LS) and 4-5 LS, respectively. All plots were rated for weed control efficacy and crop injury 30 days after treatment. Application of pendimethalin ACS at 2.2 or 4.4 kg/ha caused no injury in 2008 or 2009 at any application timing. In 2009, the higher rate of pendimethalin ACS increased early-season control of ladysthumb from 53 to 83% and redroot pigweed from 55 to 85%, when compared to the lower rate. Flumioxazin applied PRE at 0.036 kg/ha caused no injury or yield reduction in 2008 or 2009. Applying flumioxazin at 0.036 or 0.072 kg/ha to onions at the 2 LS did not result in significant crop injury and provided excellent burndown activity on many of the broadleaf weed species present in 2008 and 2009. Applying flumioxazin in a tank mix with labeled rates of pendimethalin EC, dimethenamid-p, or s-metolachlor resulted in serious stunting, stand thinning, and 48-63% yield reduction in 2008 and 56-78% yield reduction in 2009.

PRE application of dimethenamid-p at 1.10 kg/ha caused 18-30% injury in 2008 and 28-35% injury and stunting in 2009. PRE application of acetochlor at 1.12 kg/ha caused 23-35% injury in 2008 and 25-35% injury in 2009. Sequential application of acetochlor resulted in stunting and 20% yield reduction in 2008. PRE application of s-metolachlor at 1.46 kg/ha caused 20-28% injury and stunting in 2009. In 2008, sequential application of s-metolachlor caused stunting and 22% yield reduction. Acetochlor, dimethenamid-p and s-metolachlor gave 65-93% yellow nutsedge control in 2008 and 68-75% control in 2009 and were the only herbicides that provided adequate control of yellow nutsedge. Propachlor at 4.5 kg/ha produced no onion injury or yield reduction in 2008 or 2009 and provided moderate to good control of most weed species. Ethofumesate at 1.12 kg/ha resulted in no onion injury but did not provide sufficient control of the weed species present.

USE OF FOMESAFEN IN IRRIGATED POTATO (SOLANUM TUBEROSUM). Collin P. Auwarter and Harlene Hatterman-Valenti, Research Specialist and Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105

Field research was conducted at the Northern Plains Potato Growers Association Irrigation Research site near Inkster, ND to evaluate potato tolerance and weed control of fomesafen +/- s-metolachlor or +/- prepackaged mix of s-metolachor and metribuzin to standards using four popular varieties grown under irrigation in North Dakota (Blazer, Russet Norkotah, Shepody, and Dakota Pearl). Seed pieces (2 oz) were planted on 36 inch rows and 12 inch spacing on May 24, 2009. Plots were 4 rows by 20 ft arranged in a randomized complete block design with 4 replicates. Herbicide treatments were applied 24 DAP with a CO_2 pressurized sprayer equipped with 8002 flat fan nozzles with a spray volume of 20 GPA and a pressure of 40 psi. Extension recommendations were used for cultural practices throughout the year.

At time of application Blazer was 80% emerged, Russet Norkotah was 75%, Shepody was 60%, and Dakota Pearl was 95%. Plants emerged at application ranged from barely poking through soil up to 1 inch in height. Dakota Pearl, with the most emerged, showed the greatest tolerance with treatments applied with fomesafen 5 DAA showing between 5-16% injured. Other varieties had between 6-28% visual injury with chlorosis as the main symptom.

Potatoes treated with fomesafen and the premix of s-metolachlor plus metribuzin (Reflex @ 2 pt/a + Boundary @ 4 pt/a) had the greatest injury 5 DAA; Blazer-26%, Russet Norkotah and Shepody-28%, and Dakota Pearl-16%. This treatment also provided 100% control of common lambsquarters throughout the trial. By 14 DAA, all treatments where fomesafen was applied still showed signs of injury ranging between 1 to 9%, and by 26 DAA, injury was reported between 0 to 2%.

Treatments with fomesafen alone had less control of common lambsquarters than treatments tank mixed with either a prepackaged mix of s-metolachor and metribuzin, metribuzin, s-metolachlor, or rimsulfuron throughout the trial.

Russet Norkotah had the greatest yields, while Blazer was the lowest yielding variety. The marketable yields (>4 oz) were similar to total yields. Dakota Pearl had the greatest tuber counts with the untreated having the most tubers in 20 ft of row (259 tubers). However, this variety also had the most unmarketable tubers with between 53 and 69% of the tubers considered culls. Shepody had the least tuber number with all treatments having less than 141 tubers in 20 ft of row.

GLYPHOSATE DRIFT TO DRYLAND RED POTATOES. Harlene M. Hatterman-Valenti and Collin P. Auwarter, Professor and Research Specialist, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105

Field research was conducted at the Northern Plains Potato Grower's Association Research site near Grand Forks, ND to evaluate three red potato cultivar's (Red Lasoda, Red Norland, and Sangre) response to glyphosate simulated drift that may have occurred to plants at one of three growth stages (tuber initiation, early bulking, and late bulking. Glyphosate was applied at rates one-third, one-sixth, and one-twelfth the standard use rate (0.25, 0.125, and 0.0625 lb ai/A) at the tuber initiation (TI), early tuber bulking (EB), and late tuber bulking stages (LB).

Seed pieces (2 oz) were planted on 36-inch rows and 12-inch spacing on June 10, 2009. Plots were 4 rows by 25 ft arranged in a split-block design with cultivar as the main factor and the combination of application timing and herbicide rate as sub-plots with 3 replicates. Glyphosate was applied with a CO_2 pressurized sprayer equipped with 8001XR flat fan nozzles with a spray volume of 5 GPA and a pressure of 35 psi. The first application timing (TI) occurred on July 23, 2009. Extension recommendations were used for cultural practices throughout the year.

Red Norland appeared to be the most sensitive cultivar to glyphosate. Plants treated with glyphosate at the TI stage or with at least 0.125 lb ai/A glyphosate at the EB stage produced significantly more cull tubers (< 4 oz) compared to the untreated control. In contrast, potatoes treated with glyphosate at the TI stage or with at least 0.125 lb ai/A glyphosate at the EB stage produced significantly less 4-6 oz. tubers compared to the untreated and other treatments. This resulted in 37 to 50% decrease in marketable tubers size-wise. Unfortunately, excessive tuber cracking and russet skinning occurred with most of the tubers in these application timings, further reducing marketable yields. A slight shift to smaller tubers occurred when plants were treated with 0.063 lb ai/A glyphosate at the EB stage. No yield differences and few visible tuber defects were observed when plants were treated with glyphosate at the LB stage.

Red LaSoda was the next most sensitive cultivar to glyphosate. Plants treated with 0.25 lb ai/A glyphosate at the TI stage or with at least 0.125 lb ai/A glyphosate at the EB stage produced significantly more cull tubers (< 4 oz) compared to the untreated control. Other grade categories were similar regardless of the glyphosate treatments. Marketbale yields were reduced 34 to 57% when plants were treated with 0.25 lb ai/A glyphosate at the TI stage or with at least 0.125 lb ai/A glyphosate at the EB stage. Excessive tuber cracking and russet skinning was most severe in the EB stage with 70 to 100% rejection of marketable tubers due to visible tuber defects.

Sangre was the least sensitive tested cultivar to glyphosate. Plants treated with 0.25 lb ai/A glyphosate at the TI or EB stage produced significantly more cull tubers (< 4 oz) compared to the untreated control. Other grade categories were similar regardless of the glyphosate treatments. Marketbale yields were reduced 31 to 58% when plants were treated with 0.25 lb ai/A glyphosate at the TI or EB stage. Excessive tuber cracking and russet skinning was most severe in the EB stage with 30 to 100% rejection of marketable tubers due to visible tuber defects.

TOLERANCE OF SWEET CORN TO BROADCAST FLAMING AT DIFFERENT GROWTH STAGES. Santiago M. Ulloa*, Avishek Datta, Stevan Z. Knezevic, Goran Malidza, and Robert Leskovsek. Graduate Student, Post Doctoral Research Associate, and Associate Professor, Haskell Agricultural Laboratory, University of Nebraska, Concord, NE 68728, USA; Research Associate, Institute of Field and Vegetable Crops, M. Gorkog 30, Novi Sad, 21000, Serbia; Graduate Student, Agricultural institute of Slovenia, Hacquetova 17, 1000, Ljubljana, Slovenia.

Propane flaming could be a potential alternative tool for weed control in organic sweet corn production. However, sweet corn tolerance to broadcast flaming must be determined first in order to optimize the use of propane. Therefore, field studies were initiated at the Haskell Agricultural Laboratory, Concord, NE in 2008 and 2009 to determine sweet corn response to five propane rates applied at three different growth stages, including: V2 (2 leaves), V5, and V7. The propane rates included were 0, 12, 24, 42, and 75 kg/ha (0, 2.5, 5, 8.5, and 15 gal/acre). Flaming treatments were applied utilizing an ATV mounted flamer moving at a constant speed of 6.5 km/h (4 m/h). The response of sweet corn to propane flaming was evaluated in terms of visual injury ratings (1, 7, 14, and 28 DAT), plant height reduction, effects on yield components (plants/m^2, tillers/plant, cob/plant, cob length, and numbers of kernels/cob), and fresh marketable yield loss. The response of different growth stages of sweet corn to propane rates was described by log-logistic models. Based on yield reduction, V7 was the most tolerant and V2 was the least tolerant stage for broadcast flaming. For example, a 5% yield reduction was evident with 23, 25, and 36 kg/ha rate of propane for V2, V5, and V7 growth stages, respectively. These results suggest that flaming has a great potential to be used effectively in organic sweet corn production. santiago@huskers.unl.edu

TOLERANCE OF POPCORN HYBRIDS TO MESOTRIONE, TEMBOTRIONE AND TOPRAMEZONE. Thomas T. Bauman and Michael D. White, Professor, Research Associate, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN. 47907.

Popcorn is an important crop on many farms in Indiana. Weed control in popcorn can be challenging because popcorn hybrids vary greatly in their response to herbicide application and herbicide options are more limited for popcorn than for dent corn.

Field trials were conducted in 2007 and 2009 to determine the impact of X and 2X rates of mesotrione, tembotrione and topramezone on three popcorn hybrids. Mesotrione was applied at rates of 105 and 210 g ai/ha. Crop oil concentrate (Herbimax) (1% v/v) was added to the mesotrione treatments. Tembotrione was applied at rates of 92 and 184 g ai/ha. Methylated seed oil (MSO Concentrate) (1.0% v/v) and 28% UAN (3.5 l/ha) were added to tembotrione treatments. Topramezone was applied at rates of 19 and 37 g ai/ha. Methylated seed oil (MSO Concentrate) (1.0% v/v) and 28% UAN (2.5 % v/v) were added to both rates of topramezone. Spray volume for the post-emergence treatments was 187 l/ha. Plots were maintained weed free for the entire growing season with a pre-emergence application of s-metolachlor+atrazine (3.2 kg/ha) and mechanical cultivation.

The three hybrids differed greatly in their response to the different herbicides. All of the popcorn hybrids showed some bleaching of treated leaves, but varied in their sensitivity to the HPPD herbicides. No injury was visible from any treatment later in the season. More injury was observed from treatment with mesotrione than from tembotrione or topramezone in 2007. In 2009 less injury was observed with tembotrione than with the other two herbicides. The 2X rates caused more injury than the X rates in both years. No difference in grain yield was observed for any of the hybrids in spite of injury observed early in the season. HPPD herbicides can cause significant injury to popcorn, but this injury may not result in a reduction in popcorn yield.

TIMING OF HERBICIDE APPLICATION FOR *PHRAGMITES AUSTRALIS* (COMMON REED) CONTROL. Ryan E. Rapp* and Stevan Z. Knezevic, Graduate Student and Associate Professor, Department of Agronomy and Horticulture, University of Nebraska, Concord, NE 68728.

Herbicides are typically used as the primary method of weed control. Since Phragmites infestations are relatively large in the State of Nebraska, determining the most appropriate timing of herbicide application is critical for developing weed management programs. Various control methods for common reed have been suggested, including mowing, burning, drainage, and herbicide application. Therefore, field studies were conducted in 2007 and 2008 along the Platte River on three locations with the objective to determine the effect of herbicide timing on weed control. Each experiment was setup as a randomized complete block design with three replications with 3 by 9 meter plots. Visual ratings were done to determine level of control. ANOVA of plant growth responses to the control methods was performed using PROC GLM to test data normality and significance ($P < 0.05$). Three herbicides (glyphosate, imazapyr and imazamox) with two different rates were applied at three different timings (1 meter tall, flowering and half through seedfill. In general, Phragmites showed more tolerance to applications during earlier timings, with control ratings increasing with later timings. Glyphosate provided the highest levels of control (>85%) after 30 days after treatment. Imazamox provided the lowest level of control throughout all timings and rates (60%) 30 days after treatment. Imazapyr and glyphosate provided the highest levels of control by the end of the growing season (90%) and into the next growing season. Imazamox provided the least amount of control (<50%) at the first application time with both rates, but improved with later timings (>68%). rappr@huskers.unl.edu

EFFECTS OF CALCIUM CARBONATE, SODIUM CARBONATE, AND IMAZAPYR FOR VEGETATION CONTROL ON SANDBARS ALONG MISSOURI RIVER. Avishek Datta*, Stevan Z. Knezevic, Charles A. Shapiro, Jon Scott, and Mike Mainz. Post Doctoral Research Associate, Associate Professor, Professor, Research Technologist, and Research Technologist, Haskell Agricultural Laboratory, University of Nebraska, Concord, NE 68728.

In an effort to increase suitable nesting habitats for two endangered bird species, Piping Plovers (*Charadrius melodus*) and Interior Least Terns (*Sterna antillarum*), a series of sandbars are being constructed along the Missouri River. Lack of bare sand areas due to vegetative overgrowth is one of the causes for the reduction of nesting habitats. It is important to identify management practices that will maintain sandbars free of vegetation; thus, protect proper nesting habitats for the bird species. Therefore, field studies were initiated on two existing sandbars (river miles 837 and 838) in 2007 and 2008 near Springfield, SD, with the objective to test vegetation control as influenced by calcium carbonate, sodium carbonate, imazapyr, and their interactions. The experiment was arranged as a split plot design with 18 treatments replicated four times where the main plot was soil amendment (calcium carbonate or sodium carbonate) surface applied at three rates (0, 3, and 6 t/ha) and the sub-plot was a rate of imazapyr (0, 0.56, and 1.68 kg/ha). The site had natural infestations of various weed species, including: cocklebur, common ragweed, horsetail, marestail, nutsedge, sweet clover, waterhemp, and wild sunflower. Imazapyr applied alone at 1.68 t/ha or following either with a 3 or 6 t/ha calcium carbonate treatment provided about 80% overall vegetation control for up to two years after application. However, applications of calcium carbonate or sodium carbonate alone or a combination of sodium carbonate and imazapyr did not provide adequate overall vegetation control for two seasons.
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EMERGENCE PATTERN OF CUT-LEAVED TEASEL. George O. Kegode, Assistant Professor, Agriculture Department, Northwest Missouri State University, Maryville, MO 64468-6001.

Cut-leaved teasel (*Dipscacus lacianatus* L.), a monocarpic biennial/perennial, is found in several US states and designated as a noxious weed in Colorado, Iowa, Missouri, and Oregon. Cut-leaved teasel establishes in low maintenance areas, such as roadsides, where mowing is a common method of vegetation management. Cut-leaved teasel is spread primarily by seed and mowing of mature plants facilitates seed dispersal. A study was conducted to evaluate cut-leaved teasel emergence pattern from early and late maturing seed. Cut-leaved teasel seeds were harvested in August and November 2008 from mature inflorescences at six sites of varied disturbance frequency across northwest Missouri. Half of the seeds were stratified at 5 C and the rest kept at room temperature until emergence tests were conducted in early 2009. Stratified and non-stratified seeds were sown in flats containing greenhouse potting mixture, placed in an environment-controlled greenhouse, and seedling emergence monitored for 28 days. Cumulative emergence percentages for August harvested seeds ranged from 64 to 93%. Stratification had no effect on emergence of the August seeds. Emergence of non-stratified cut-leaved teasel seeds harvested in November ranged from 1 to 12%, whereas emergence from stratified seeds ranged from 10 to 48%. Emergence data suggests early maturing cut-leaved teasel seeds lack dormancy, as compared to later maturing seeds. The higher percentage emergence of early-maturing teasel seeds across sites, compared to late maturing seeds suggests early dispersed seeds could potentially germinate, emerge, and produce rosettes that could overwinter and mature during the following growing season.

CHEMICAL CONTROL OF SALTCEDAR IN SOUTHWEST KANSAS. Walter H. Fick and Wayne A. Geyer, Associate Professor, Department of Agronomy and Professor, Department of Horticulture, Forestry and Recreation Resources, Kansas State University, Manhattan, KS 66506.

Saltcedar (*Tamarix ramosissima* Ledeb.) is an invasive woody tree found throughout the western U.S. along rivers, streams, and wetlands. In Kansas, over 20,000 ha of saltcedar exists primarily along the Arkansas and Cimarron rivers. The objective of this research was to compare the efficacy of herbicides applied either as cut-stump or foliar treatments for saltcedar control. The study site was located on the Cimarron National Grassland located in southwest Kansas and managed by the United States Forest Service. Saltcedar was cut during July 2008 using a 71-cm rotary saw attached on the front end of a tractor. Cut-stump and foliar treatments were applied on July 31, 2008 and evaluated October 3, 2008 and July 27, 2009. Cut-stump treatments were replicated 10 times and were applied using a 3.8 L garden sprayer. Treatments included glyphosate (50% v/v), imazapyr (10% v/v), glyphosate + imazapyr (5 + 5% v/v), triclopyr (10 and 25% v/v in diesel), and triclopyr + fluroxypyr (18.75 + 6.25% v/v in diesel). Foliar treatments included high-volume applications of imazapyr as 0.5 and 1% solutions in water and imazapyr + glyphosate at a 0.5 + 1% rate. These treatments were applied to 15 to 20 trees using a backpack sprayer. All cut-stump treatments provided 100% control of saltcedar 2 months after treatment (MAT). All treatments except glyphosate at 50% v/v and triclopyr at 10% v/v in diesel provided 100% control 1 year after treatment (YAT). Foliar applications of imazapyr at 0.5 to 1% v/v solutions provided 35 to 48% defoliation of saltcedar 2 MAT. The combination of imazapyr + glyphosate at 0.5 + 1% v/v in water provided 68% defoliation 2 MAT. By 1 YAT the three foliar treatments provided 56 to 73% mortality of saltcedar. Saltcedar is a difficult tree to kill, but cut-stump and foliar treatments exist that can provide significant control. Follow-up control may be necessary to increase mortality of saltcedar initially treated with foliar-applied herbicides.

ABSINTH WORMWOOD CONTROL PROGRAMS THAT INCLUDE MOWING, FERTILIZATION, OR HERBICIDES. Michael J. Moechnig, Darrell L. Deneke, Jill K. Alms, and David A. Vos, Assistant Professor, IPM Coordinator, Senior Ag Research Technician, and Ag Research Manager, Plant Science Department, South Dakota State University, Brookings, SD 57007.

Absinth wormwood (*Artemisia absinthium*) is a perennial invasive weed that may be found in many northern U.S. states from Kansas to North Dakota and from Oregon to Maine. Previous research has indicated absinth wormwood can reduce pasture grass production by 65%. Absinth wormwood can also invade new native grass/forb plantings. In such situations, non-herbicide control options may be desired to prevent injuring native forb species that are costly to plant. A field study was established from 2007 to 2009 in northeastern South Dakota to evaluate combinations of mowing, fertilizer, and herbicides to control absinth wormwood in a grassland that was planted approximately two years prior to initiation of this study. Grass species primarily included big bluestem, Russian wildrye, sideoats grama, and switchgrass. Treatments included spring mowing, spring and fall mowing, spring and fall mowing with 90 kg/ha N applied in spring, spring and fall mowing with 90 kg/ha N applied in fall, and 2,4-D ester or picloram plus 2,4-D ester applied in spring or in the fall after spring mowing. None of the mowing treatments resulted in noticeable absinth wormwood control after two years of mowing, but several of the herbicide treatments resulted in greater than 94% control the first year after application. The spring application of 2,4-D ester at 2.1 kg ae/ha without mowing resulted in greater control than 2,4-D applied at the same rate in the fall after spring mowing. This may be partially due to grass growth reduction caused by mowing. At two years after mowing, grass shoot biomass in the mowed treatments was 32 to 64% less than that in the most effective herbicide treatment. Grass yield in the untreated treatment was similar to grass yield in the mowed treatments one year after initiation of this study, but on the second year grass yield in the untreated treatment was nearly twice as great as some of the mowed treatments. These results suggested the grass was becoming more competitive with absinth wormwood and absinth wormwood management would be more effective if nothing was done rather than mowing. Conclusions from this study were that mowing or mowing plus fertilization were not effective management options for absinth wormwood after two years but herbicides were effective just one year after application. Perhaps future research regarding non-herbicide control options for absinth wormwood in new grassland plantings should include methods of increasing the competitive ability of grasses.

LEAFY SPURGE CONTROL WITH TANK-MIXES OF IMAZAPIC AND SAFLUFENACIL APPLIED IN FALL. Stevan Z. Knezevic, Avishek Datta, Ryan E. Rapp, Jon Scott, Leo D. Charvat*, and Joseph Zawierucha. Associate Professor, Post Doctoral Research Associate, Graduate Student, and Research Technologist, Haskell Agricultural Laboratory, University of Nebraska, Concord, NE 68728; Biology Area Manager, BASF Corporation, Lincoln, NE 68523 and Biology Project Leader, BASF Corporation, RTP, NC 27709.

Saflufenacil is a new herbicide being primarily developed for pre-plant burndown and PRE broadleaf weed control in field crops and non-cropland areas. Leafy spurge is a serious weed problem in North American range and pastureland. Imazapic is commonly used for leafy spurge control as a fall treatment. Our hypothesis was that there might be synergism between imazapic and saflufenacil if applied in fall. Field trials were initiated during fall of 2007 and 2008 with the objective to describe dose-response curves of saflufenacil tank-mixed with imazapic in order to determine the best ratios of the two for leafy spurge control. Saflufenacil rates were 0, 12.5, 25, 50, and 100 g/ha, imazapic rates were 0, 35, 70, and 105 g/ha. Dose-response curves based on log-logistic model were used to determine the ED_{90} values of saflufenacil for each imazapic level. Imazapic rate of 105 g/ha applied alone provided about 90% control at 240 DAT and about 80% control at 300 DAT. Saflufenacil applied alone provided excellent control but only for 30 DAT depending on the rates used, then the leafy spurge started re-growing. Imazapic rate of 35 and 70 g/ha applied alone provided about 65% control for 240 DAT. The ED_{90} values (90% control) of saflufenacil in the tank-mix with imazapic rates of either 35 or 70 g/ha were around 20-25 g/ha for control up to 275 DAT suggesting synergism between the two herbicides at those rates. There were also some grass injuries of about 10-20% with 105 g/ha of imazapic. sknezevic2@unl.edu

LEAFY SPURGE CONTROL WITH TANK-MIXES OF IMAZAPIC AND SAFLUFENACIL APPLIED IN SPRING. Stevan Z. Knezevic*, Avishek Datta, Ryan E. Rapp, Jon Scott, Leo D. Charvat, and Joseph Zawierucha. Associate Professor, Post Doctoral Research Associate, Graduate Student, and Research Technologist, Haskell Agricultural Laboratory, University of Nebraska, Concord, NE 68728; Biology Area Manager, BASF Corporation, Lincoln, NE 68523 and Biology Project Leader, BASF Corporation, RTP, NC 27709.

Leafy spurge is a serious weed problem in North America infesting over five million ha of rangeland and pasture. Imazapic is commonly used for leafy spurge control as a fall treatment only, because spring applications do not provide satisfactory control. Saflufenacil is a new herbicide being primarily developed for pre-plant and PRE broadleaf weed control in field crops and non-crop areas**.** Our hypothesis was that there might be synergism between imazapic and saflufenacil if applied in spring. Field experiments were conducted during spring of 2007 and 2008 with the objective to describe dose-response curves of imazapic and saflufenacil applied alone and tank-mixed. Saflufenacil rates were 0, 12.5, 25, 50, and 100 g/ha, imazapic rates were 0, 52.6, 105, and 158 g/ha. Dose-response curves based on log-logistic model were used to determine the ED_{90} values of saflufenacil for each imazapic level. In general, none of the imazapic rates applied alone provided satisfactory leafy spurge control. Saflufenacil applied alone provided excellent leafy spurge control for only 30-90 DAT depending on the rates used, then the leafy spurge started re-growing. In contrast, the longest control of leafy spurge (400 DAT) was achieved with saflufenacil ED_{90} rate of about 25 g/ha tank-mixed with 105 g/ha of imazapic. There was also cool season grass injury (10-30%) with 158 g/ha of imazapic, which lasted for six weeks only. Results from this study indicated that indeed there is a synergism between the two herbicides; additional studies are needed to determine the mechanism of such synergy. sknezevic2@unl.edu

WEEDY TRANSGENIC VOLUNTEER CORN IN CORN AND THE EFFECT ON CORN ROOT DAMAGE BY WESTERN CORN ROOTWORM. Paul T. Marquardt*, Christian H. Krupke, and William G. Johnson, Research Associate, Department of Botany and Plant Pathology, Assistant Professor, Department of Entomology, Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Volunteer corn expressing herbicide-resistance is a problematic weed in continuous corn production. This issue is partially due to the increasing prevalence of stacking both herbicide and insect-resistant (mainly Bt) traits into the same genetically-modified plant. The increase is attributed to the 2003 introduction and adoption of corn expressing Bt traits targeting the western corn rootworm (WCR), the most damaging insect in corn production. Previous research indicates that the Bt concentration in volunteer corn may be less than the Bt concentration of adjacent hybrid corn. Thus, volunteer corn expressing Bt may increase Bt selection pressure on WCR populations and the likelihood of root damage to adjacent hybrid plants. Our objectives were to quantify the concentration of Bt expressed in volunteer corn root tissue and to determine the effect of volunteer corn on adjacent hybrid corn root damage. We sampled volunteer corn root tissue from corn and soybean fields and measured the Bt concentration using quantitative ELISA. Roots of Bt positive and negative volunteer corn and the corresponding hybrid corn within 0.5 m of the volunteer corn were sampled and rated for damage. Volunteer corn expresses twice the concentration of Bt in corn than in soybean. Also, volunteer corn expressing Bt does not impact the amount of damage sustained by hybrid corn plants less than 0.5 m from volunteer plants (positive or negative for Bt). In-field factors such as soil nutrient levels (nitrogen, sulfur, etc) may ultimately affect the expression of Bt in volunteer corn plants. Due to the higher nitrogen levels in corn fields, volunteer corn in corn may not affect the efficacy of adjacent hybrid Bt corn on WCR.

RATE OF *IN SITU* SHATTERCANE X SORGHUM HYBRIDIZATION. Jared J. Schmidt, John L. Lindquist, Mark L. Bernards and Jeff F. Pedersen, Graduate Research Assistant, Associate Professor, Assistant Professor, Department of Agronomy and Horticulture, University of Nebraska, Lincoln NE 68583, Research Geneticist, USDA-ARS, University of Nebraska, Lincoln NE 68507.

Sorghum (*Sorghum bicolor* subsp. *bicolor*) can interbreed with its close weedy relative shattercane (*S. bicolor* subsp. *drummondii*). An *in situ* experiment was conducted to determine the potential for pollen-mediated gene flow from sorghum to shattercane. Shattercane with juicy midrib (*dd*) was planted in a soybean field in concentric arcs at varying distances from a sorghum pollen source with dry midrib (*DD*). The arcs were placed so that prevailing winds would carry pollen from the sorghum to shattercane. Shattercane panicles in anthesis during sorghum pollen shed were tagged and seeds were collected from those shattercane panicles. Shattercane progeny were scored for the dominant phenotypic marker to determine outcrossing rate. Outcrossing was greatest (3.6±0.06%) for shattercane planted within the sorghum field and generally declined as distance from the source increased. Progeny from 101 of the 105 panicles evaluated at ≤10m contained outcrossed seed with the highest percentage of outcrossing for a panicle of 10.2%. Outcrossing was noted in 9 of the 73 panicles grown at the farthest distance evaluated (200m) with the highest outcrossing individual having 2.4%. Results indicate that genes from sorghum could be introduced into shattercane populations by cross-pollination at distances of at least 200m. Two of the 307 panicles evaluated (both 40m from source) had outcrossing rates greater than 40%. This might be due to environmental or genetic factors inducing protogyny or male sterility. Further tests are being conducted to examine the cause.

INVESTIGATING THE DISSEMINATION OF HERBICIDE RESISTANCE IN WATERHEMP. Jianyang Liu, Patrick J. Tranel, and Adam S. Davis, Postdoctoral Research Assistant and Professor, Department of Crop Science, University of Illinois, Urbana, IL 61801, Ecologist, USDA-ARS, Urbana, IL 61801.

Glyphosate-resistant (GR) waterhemp poses a great threat to crop production in the midwestern United States. Seed and pollen dispersal contribute to the dissemination of GR waterhemp, and this dispersal may be facilitated by anthropogenic forces. We conducted field surveys to model the dynamics of a GR waterhemp population in south-central Illinois during 2008 and 2009. This population was identified as GR in 2006. In 2008, seed collections (accessions) from single females were obtained within an approximately 30-ha area around the initial resistant population. Glyphosate treatment of plants grown from these seed collections indicated that GR waterhemp plants could be found throughout the sampled area. However, accessions did not have uniform frequencies of resistant individuals. More widespread sampling was performed in 2009, with over 900 accessions collected in an area ranging up to 45 km from the original field site. These accessions are currently being analyzed for glyphosate resistance. Tissue samples were also obtained in 2009 from the maternal plants of each accession. Glyphosate resistance in maternal plants will be determined using a molecular assay. Resistance data from both maternal plants and their progeny should enable estimation of the relative contributions of seed vs. pollen movement to the dissemination of GR waterhemp.

RELATIVE TOLERANCE OF UNIQUE HORSEWEED (*CONYZA CANADENSIS*) POPULATIONS TO 2,4-D. Melissa M. Kruger, Greg R. Kruger, Vince M. Davis, Stephen C. Weller, and William G. Johnson, Research Associate, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN, 47907, Graduate Research Assistant, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN, 47907, Assistant Professor, Department of Crop Sciences, Urbana, IL 61801, Professor, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907, and Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN, 47907.

Since the introduction of glyphosate-resistant soybean in 1996, growers have relied heavily on postemergence glyphosate for weed control in no-till soybean. This weed management strategy has led to the evolution of several glyphosate-resistant weeds including horseweed. With the evolution of resistant weed species and the advent of 2,4-D resistant traits, 2,4-D will provide another herbicide to apply with glyphosate for added control of glyphosate-resistant horseweed. The objective of this study was to determine the effect of 2,4-D on four Indiana horseweed populations with varying tolerance to 2,4-D. The study included treatments of 0, 140, 280 and 560 g ae/ha of 2,4-D amine and an additional treatment of 280 g/ha of 2,4-D plus 840 g ae/ha of glyphosate. The horseweed seeds were germinated in the greenhouse and then transplanted into the field when seedlings were 4 cm in diameter. The plants were sprayed when they were between 5 and 10 cm tall. At least one plant survived from three of the four populations tested that went on to produce seed following application of 280 g/ha of 2,4-D plus 840 g/ha of glyphosate. After exposure to 560 g/ha of 2,4-D, one population had a plant that produced seed. However, 2,4-D at 280 g/ha reduced seed production by greater than 95% in each of the four populations tested. Variable responses of individual plants in each of the four populations suggests that there is potential for the evolution of 2,4-D resistance in horseweed.

KOCHIA DIFFERENTIAL RESPONSE TO GLYPHOSATE. Jason Waite, Kassim Al-Khatib, Graduate Research Assistant, Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Kochia is becoming a more troublesome weed in cropping systems. There are several management strategies for kochia which include tillage, chemical burndown as well as postemergence selective herbicide treatments. With the widespread use of glyphosate resistant crops there has been an increased use of glyphosate to control kochia in resistant crops that led to less susceptible populations of kochia. A greenhouse study was conducted to evaluate the differential response of 10 kochia populations to glyphosate. Plants were treated when average kochia height was 15 cm. Injury was rated at 7, 14 and 21 days after treatment (DAT). Kochia height and biomass were taken 21 DAT. Injury ratings were based on 0 = no injury and 100 = plant mortality. Glyphosate rates were 1/16, 1/8, 1/4, 1/2, 1, 1 and 1/2, 2, 4 and 6 times a use rate of 870 g ae/ha. Glyphosate rate required to cause 50% injury was calculated (GR_{50}). Out of 10 kochia populations, 3 populations were less sensitive to glyphosate with a GR_{50} range from 2.47 to 1.52. In addition, three of the populations showed intermediate susceptibility to glyphosate with a GR_{50} range from 0.79 to 0.75. Furthermore, four kochia populations were susceptible to glyphosate with a GR_{50} range from 0.69-0.54. This study clearly illustrates that differential kochia response to glyphosate exists between populations.

MULTITACTIC WEED MANAGEMENT IN ORGANIC SOYBEAN PRODUCTION SYSTEMS. Emily R. Bernstein, David E. Stoltenberg, Joshua L. Posner, and Janet L. Hedtcke, Graduate Research Assistant, Professor, Professor and Senior Research Specialist, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

Organic soybean production has rapidly increased in Wisconsin to meet demand of the expanding organic dairy industry. A major challenge faced in these production systems is the intensive tillage needed for successful weed management, spurring interest in more systems oriented, multitactic approaches to weed management. However, little is known about the effectiveness and risks associated with such approaches. We conducted research in 2008 and 2009 near Arlington, Wisconsin to determine some of the weed management and environmental risks and benefits associated with the use of a winter rye cover crop for no-tillage organic soybean production relative to a tillage-intensive approach (plowing, tine weeding, and cultivation). In the no-tillage approach, rye mulch and soybean competitive ability are the principal tactics relied upon for weed management, whereas in the tillage-intensive approach, tine weeding and cultivation are the principal tactics. As such, our specific objectives were to determine the effect of rye management (plowing, crimping, and mowing), soybean planting date (mid-May or early June), and soybean row spacing (19 or 76 cm) on soybean stand establishment, weed suppression, weed community composition, and soybean yield. Treatment effects on economic gross margins, soil loss, and soil quality were also predicted.

At the time of rye management (plowing, crimping, or mowing), rye mass was 7- to 10-fold greater in no-tillage systems than the tillage-intensive system in each year ($p < 0.0001$). In no-tillage systems, rye mass was 13.3 Mg ha^{-1} in 2008 and 5.3 Mg ha^{-1} in 2009, both years exceeding the minimum (4 Mg ha^{-1}) considered necessary for effective weed suppression. Soybean establishment (stand density as a percent of viable seeding rate) in the no-tillage systems for early-planted soybean (before rye crimping or mowing) was greater (80%) than late-planted soybean (after crimping or mowing, 60%) ($p = 0.0406$) suggesting more uniform depth placement of seed occurred in the early planted treatments. However, soybean establishment did not differ between tillage-intensive and early-planted no-tillage systems, nor was it affected by rye management (crimping or mowing) or row spacing (76 or 19 cm).

Early-season (mid-June) weed densities and community composition among treatments varied by year, except that velvetleaf was more abundant in the tillage-intensive system than no-tillage systems in each year. In 2008, weed densities at VE-V2 soybean were greater in the tillage-intensive system (44 weeds m^{-2}) than across no-tillage systems (0.2 weeds m^{-2}) ($p < 0.0001$). Yellow foxtail (14 plants m^{-2}), velvetleaf (13 plants m^{-2}) and shepard's-purse (13 plants m^{-2}) were the most abundant species in the tillage-intensive system, whereas yellow foxtail (0.1 plants m^{-2}) and common lambsquarters (0.1 plants m^{-2}) were the most abundant species across no-tillage systems. In 2009, weed densities at VC-V3 soybean did not differ among treatments ($p = 0.7938$), and averaged 11 weeds m^{-2}. The most abundant species in the tillage-intensive system were common lambsquarters (5 plants m^{-2}), velvetleaf (2 plants m^{-2}) and shepard's-purse (1 plants m^{-2}). In no-tillage systems, common lambsquarters (5 plants m^{-2}), shepard's-purse (4 plants m^{-2}) and white clover (3 plants m^{-2}) were most abundant. Early-season weed species abundance was not affected by soybean planting date, row spacing, or rye management among no-tillage systems.

Weed suppression was greatest in the no-tillage systems, as late-season total weed shoot mass across years was several-fold greater in the tillage-intensive system than in the no-tillage systems ($p = 0.0058$). Among no-tillage systems, weed mass was less for earlier- than later-planted soybean ($p = 0.0612$) and for narrow- than wide-row spacing ($p = 0.0991$). Abundant species differed between tillage-intensive and no-tillage systems in each year. In 2008, the most abundant species (based on mass) in the tillage-intensive system were velvetleaf (49 g m^{-2}), redroot pigweed (4 g m^{-2}) and barnyardgrass (1 g m^{-2}), compared to common lambsquarters (3 g m^{-2}), barnyardgrass (1 g m^{-2}) and velvetleaf (0.7 g m^{-2}) in the no-tillage systems. Weed species richness (Margalef's index; $p = 0.3099$), evenness (Pielou's index; $p = 0.3253$), and diversity (Shannon's index; $p = 0.9186$) did not differ between the tillage-intensive and no-tillage systems. In 2009, the most abundant species in the tillage-intensive system were common lambsquarters (128 g m^{-2}), velvetleaf (5 g m^{-2}), and ladysthumb (2 g m^{-2}). In contrast, the most abundant species in the no-tillage systems, were common lambsquarters (10 g m^{-2}), ladysthumb (3 g m^{-2}), and white clover (3 g m^{-2}). Weed species richness ($p=0.0007$), evenness ($p = 0.0015$), and diversity ($p < 0.0001$) were greater in no-tillage systems than the tillage-intensive system.

Soybean yield across years was greater for the tillage-intensive system than any of the no-tillage systems ($p = 0.0041$). Among no-tillage systems, soybean yield was greater for narrow- than wide- row spacing ($p = 0.0883$), but yield was not affected by planting date ($p = 0.1636$) or rye management ($p = 0.7667$). The tillage-intensive system was also more profitable than the no-tillage systems ($p = 0.0054$). However, profitability was not affected by rye or soybean management among the no-tillage systems. Predicted soil loss was several-fold greater for the tillage-intensive system than no-tillage systems at both 1 and 4.5% slopes. Soil loss for the no-tillage systems was less than the T-value (11 Mg ha^{-1}) in each scenario. Predicted changes in soil organic matter over time were positive in no-tillage systems and negative in the tillage-intensive system.

Multiple tactics that included winter rye mulch, no-tillage planting, and competitive crop canopies were associated with greater weed suppression and weed community dynamics, less soil loss, and greater soil organic matter than a tillage-intensive approach to organic soybean production. However, these potentially long-term benefits were offset by 24% less soybean yield and 25% less profit. Even so, these rye mulch, no-tillage soybean systems appear to be economically viable alternatives to the tillage-intensive approach; they are particularly attractive to growers due to the reduction in labor requirements, and require less organic matter inputs over the rotation in order to maintain long-term soil quality.

COVER CROP ROLLER-CRIMPER CONTRIBUTES TO WEED MANAGEMENT IN NO-TILL SOYBEAN. Adam S. Davis, Ecologist, United States Department of Agriculture/Agricultural Research Service, Invasive Weed Management Unit, Urbana, IL, 61801.

Termination of cover crops prior to no-till planting of soybean is typically accomplished with burndown herbicides. Recent advances in cover crop roller-crimper design offer the possibility of reliable physical termination of cover crops without tillage. A field study within a no-till soybean production system was conducted in Urbana, IL, from 2004-2007 to quantify the effects of cover crop (cereal rye, hairy vetch, or bare soil control), termination method (chemical burndown or roller-crimper) and postemergence glyphosate application rate (0, 1.1 or 2.2 kg a.e. ha^{-1}) on soybean yield components, weed-crop interference, and soil environmental variables. Biomass of residual weed populations within soybean following either vetch or rye was reduced by 26 and 56%, respectively, in the rolled system compared to the burndown system ($P < 0.001$). Soybean yield loss due to weed interference was unaffected by cover crop termination method ($P > 0.35$), but the interaction between cover type and postemergence glyphosate application rate was significant ($P < 0.01$). In soybean following a rye cover crop, regardless of termination method, yield under competition from weeds was unaffected by glyphosate rate, whereas in soybean following a vetch cover crop or bare soil, yield increased with glyphosate rate ($P < 0.001$). Variation in soybean yield among cover crops and cover crop termination treatments was due largely to differences in soybean establishment, rather than differences in the soil environment. Use of a roller-crimper to terminate a cover crop preceding no-till soybean has the potential to achieve similar yields to those obtained in a chemically terminated cover crop while reducing residual weed biomass.

INCREASING COVER CROP DIVERSITY AND WEED SUPPRESSIVENESS OF SOILS IN ORGANIC CROPPING SYSTEMS. Sam E. Wortman, John L. Lindquist, Rhae A. Drijber , Mark L. Bernards and Charles A. Francis, Graduate Student, Associate Professor, Professor, Assistant Professor and Professor, Department of Agronomy and Horticulture, University of Nebraska – Lincoln, Lincoln, NE, 68583-0915.

Many studies have demonstrated the weed suppressive potential and fertility contributions of individual cover crop species, but the value of diverse cover crop mixtures and soil biota have received less attention. The objective of this study is to determine the effects of cover crop diversity and termination method on weed populations, soil microbial community structure, soil nutrient availability, soil water content and grain yield in a certified organic cropping system. A split-plot RCBD field experiment was initiated in 2009 near Mead, NE. Spring-sown mixtures of 2, 4, 6 and 8 cover crop species were included in a sunflower – soybean – corn crop rotation. Cover crops were terminated in late-May using a field disk or sweep plow undercutter and summer annual crops were planted six days later. Cover crop or weed biomass/cover, soil nitrate and soil microbial communities were sampled three times throughout the season and soil water content was measured four times to a depth of 8 cm. Cover crop biomass was greatest in the 6 cover crop mixture (318 g m^{-2}) and lowest in the 2 cover crop mixture (114 g m^{-2}). Compared to the disked treatment, weed suppression and soil moisture were greater in response to the undercut treatment for cover crop termination. The increased level of weed suppression due to undercutting the cover crops may be explained by two possible hypotheses: 1) physical interference of residue reduced weed seed germination or 2) greater soil moisture increased the competitive advantage of the crop. Despite the use of many cover crop species with demonstrated allelopathic effects, the lack of weed suppression in the disked treatment indicates a lack of phytotoxic activity in the soil. Soil N levels did not affect weed suppression and the influence of the soil microbial community is currently being analyzed. Late in the growing season broadleaf weed cover was greatest in the weed/cover crop free control treatment (28.7%) and lowest in the 8 cover crop mixture (20.0%), indicating a general decrease in broadleaf weed cover as diversity of the cover crop mixture increased. Crop yield was reduced in the disked treatment presumably due to reduced levels of early-season soil moisture and weed suppression.

TEMPORAL SEED RAIN AND DORMANCY OF FIELD PENNYCRESS AND COMMON CHICKWEED. Erin C. Taylor, Karen A. Renner, and Christy L. Sprague, Research Associate, Professor, Associate Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Understanding the biology of winter annual weeds is essential for improved management strategies. Winter annual weeds are not always viewed as a priority for control because of their out-of-season presence; however winter annual weeds can be difficult to manage in the spring and some species are alternate hosts for a variety of crop pests and diseases. Over the past several years we have studied the temporal seed dispersal and subsequent dormancy of naturally occurring populations of the winter annual weeds field pennycress (*Thlaspi arvense*) and common chickweed (*Stellaria media*). When examining dispersal by growing degree days (GDD) (base 0C, starting January 1), field pennycress reached peak seed dispersal between 2251 and 2750 GDD in all four years. Common chickweed seed dispersal was less consistent with peaks being reached between 1001 and 2000 GDD. The initial dormancy of field pennycress seed varied between years. In 2006 and 2008 seeds that dispersed initially showed greater dormancy compared with seeds dispersed later, whereas in 2007 dormancy was fairly low overall with an average of 44% of fresh seed germinating at any given dispersal time. In 2009 almost no seed germinated at the time of dispersal. The initial dormancy of freshly dispersed common chickweed seeds was high (>90%) for all dispersal dates in all years except for the later collection dates in 2007 at which time 11-20% of the seed readily germinated at the time of dispersal. Field pennycress seed dormancy significantly decreased after two months of storage outside for seeds dispersed after 2751 GDD. A maximum germination rate of 85% was observed two months after dispersal for field pennycress seeds dispersed between 3501 and 3750 GDD. There was no pattern of dormancy release for common chickweed; a maximum germination rate of 70% was observed four months after seed dispersal between 2751 and 3000 GDD. Growing degree days are a good predictor of peak seed dispersal and dormancy release for field pennycress, but not for common chickweed. Other factors such as prolonged emergence patterns and predispersal seed predation may influence seed responses of common chickweed.

PULSE CROP TOLERANCE TO PYROXASULFONE. Ryan L. Hunt and Richard K. Zollinger, Graduate Research Assistant and Professor Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050.

Field experiments were established in 2008 and repeated in 2009 to evaluate the tolerance of pea, lentil, navy bean, and pinto bean to pyroxasulfone. Pea and lentil trials were located near Williston, Minot, and Carrington, ND. Navy and pinto bean trials were located near Prosper, Hatton, and Thompson, ND. All trials contained pyroxasulfone applied preemergence (PRE) at 84, 125, 166, and 332 g ai/ha. Pea showed no visual injury or significant yield differences at all locations in 2008 and 2009. Lentil showed no visual injury or significant yield differences at all locations in 2008 and at Williston and Carrington in 2009. Minimal rainfall at the beginning of the growing season at these locations likely resulted in insufficient activation of the herbicide, as evidenced by inadequate weed control. Minot lentil showed 2-15% visual injury 14 days after emergence (DAE), 4-21% 28 DAE, and 0-8% 56 DAE in 2009. This injury did not significantly affect yield of lentil. Navy bean injury 14 DAE in 2008 was 18-96%, 0-28%, and 1-46%, at Prosper, Hatton, and Thompson. 28 DAE navy bean injury was 6-93%, 0-30%, and 0-23% at Prosper, Hatton, and Thompson. 56 DAE navy bean injury was 2-99%, 0-19%, and 0-21% at Prosper, Hatton, and Thompson. Yield at Hatton and Thompson significantly decreased as rate of pyroxasulfone increased. Prosper was unable to be harvested due to weather conditions. Navy bean injury 14 DAE in 2009 was 0-20%, 0-33%, and 0-14% at Prosper, Hatton, and Thompson. 28 DAE navy bean injury was 0-8%, 0-12%, and 0-38% at Prosper, Hatton, and Thompson. 56 DAE navy bean injury was 0-1%, 0-9%, and 0-19% at Prosper, Hatton, and Thompson. Yield at Prosper and Thompson significantly decreased as pyroxasulfone rate increased, but did not significantly change at Hatton. Pinto bean injury 14 DAE in 2008 was 1-35%, 0-12%, and 0-9% at Prosper, Hatton, and Thompson. 28 DAE pinto bean injury was 2-75%, 0-9%, and 0-8% at Prosper, Hatton, and Thompson. 56 DAE pinto bean injury was 0-39%, 0-11%, and 0-4% at Prosper, Hatton, and Thompson. Yield at Hatton significantly decreased as pyroxasulfone rate increased; however, Thompson did not significantly change and Prosper was unable to be harvested due to weather conditions. Pinto bean injury 14 DAE in 2009 was 0-21% and 0-3% at Hatton and Thompson. 28 DAE pinto bean injury was 0-11% and 0-14% at Hatton and Thompson. 56 DAE pinto bean injury was 0-6% and 0-4% at Hatton and Thompson. No visual injury was observed at any rating for Prosper pinto bean. Yields were not significantly different for pinto bean at all locations in 2009. Injury values for both navy and pinto beans were higher in 2008 compared to 2009. An activating rainfall occurred in 2008 while the beans were at the cracking stage, in 2009 this did not occur until the beans were well established. Pea and lentil tolerance to pyroxasulfone was acceptable; however, dry bean tolerance was insufficient.

EFFECTIVENESS AND CONSISTENCY OF TANK-MIX PARTNERS WITH GLYPHOSATE FOR POSTEMERGENCE APPLICATIONS IN SOYBEAN. David K. Powell, Bryan G. Young, Douglas J. Maxwell, and Gordon K. Roskamp, Graduate Research Assistant, Professor, Southern Illinois University, Carbondale, IL 62901, Principal Research Specialist, University of Illinois, Urbana, IL 61801, and Professor, Western Illinois University, Macomb, IL 61455.

Field studies were conducted in eight locations in Illinois to determine any positive or negative interactions when tank-mixing postemergence broadleaf herbicides with glyphosate in glyphosate-resistant soybean. Glyphosate was applied alone (860 g ae/ha) and in combinations with lactofen (105 and 210 g ai/ha), fomesafen (165 and 330 g ai/ha), flumiclorac (30 and 60 g ai/ha), imazethapyr (70 g ai/ha), and chlorimuron + thifensulfuron (6 + 2 g ai/ha). Treatments were applied at an early postemergence EPOST weed height (8 to 13 cm) and at a late postemergence (LPOST) weed height (15 to 25 cm).

Soybean injury at 7 DAT was influenced mostly by the addition of PPO-inhibiting herbicides with injury for these combinations ranging from 10 to 31%, with the greatest amount of injury observed from lactofen at either rate. In general, soybean injury by 14 DAT decreased to approximately half of the levels observed at the 7 DAT evaluation and continued to dissipate to 5% or less for all herbicide treatments by 28 DAT. Control of common waterhemp for all herbicide combinations and application timings was 97 and 93% or greater on glyphosate-susceptible populations at 14 and 28 DAT, respectively. Control of glyphosate-resistant common waterhemp at 14 DAT was greater with full and half rates of lactofen and fomesafen combined with glyphosate than all other postemergence herbicide tank-mixtures with glyphosate. However, control of glyphosate-resistant waterhemp was still less than 90% for the combinations of lactofen and fomesafen with glyphosate. The response of other weed species to the addition of a tank-mixture with glyphosate was variable and species dependent.

OPTIMUM GAT SOYBEAN: HERBICIDE COMBINATIONS FOR PRE-PLANT BURNDOWN AND RESIDUAL WEED CONTROL. Nicholas V. Hustedde, Bryan G. Young and Joseph L. Matthews, Graduate Research Assistant, Professor, and Researcher, Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901.

The development of Optimum GAT soybean allows for the use of glyphosate and sulfonylurea herbicide combinations that would not be possible in current soybean cultivars. The herbicide combinations conceived for use in Optimum GAT soybean were evaluated at two field sites in 2009 for control of glyphosate-resistant horseweed and glyphosate-resistant common waterhemp. Herbicide treatments included: no residual herbicide, chlorimuron (17.5 g ai/ha) + rimsulfuron (17.5 g ai/ha), chlorimuron (35 g ai/ha) + rimsulfuron (35 g ai/ha), chlorimuron (17.5 g ai/ha) + rimsulfuron (17.5 g ai/ha) + flumioxazin (70 g ai/ha), and sulfentrazone (140 g ai/ha) + cloransulam (18 g ai/ha). All treatments were applied at 35, 21, and 7 days before soybean planting (DBP) in a no-till production system and included glyphosate (860 g ae/ha) + 2,4-D ester (530 g ae/ha). Glyphosate (860 g ae/ha) was applied postemergence to soybean at approximately 28 days after soybean planting (DAP).

Control of glyphosate-resistant horseweed was 95% or greater by 14 DAP when applied with any treatment containing chlorimuron + rimsulfuron, or cloransulam regardless of the pre-plant application timing. The application of glyphosate + 2,4-D without any residual herbicide resulted in less than 50% control of horseweed when applied at 35 DBP due to new emergence of horseweed. Herbicide treatment differences in control of horseweed by 28 days after the postemergence glyphosate application followed similar trends as the 14 DAP evaluations with less than adequate control for applications without a residual herbicide for horseweed.

Control of common waterhemp at 14 DAP ranged from 0 to 54% for the residual herbicides applied at 35 DBP compared with 60 to 89% control for herbicides applied at 7 DBP. The application of herbicides at 21 DBP resulted in similar or less control of common waterhemp at 14 DAP compared with the 7 DBP application timing, depending on the specific residual herbicide treatment. The combination of chlorimuron, rimsulfuron, and flumioxazin applied 7 DBP was the only treatment that resulted in greater than 75% control of common waterhemp by 14 DAP. Control of common waterhemp at 28 days after the postemergence glyphosate application was 83% or greater for all herbicide combinations at the field site located near Murphysboro, IL which was determined to contain primarily glyphosate-susceptible waterhemp. Applying chlorimuron, rimsulfuron, and flumioxazin at 7 DBP resulted in 75% control of common waterhemp by 28 days after the postemergence glyphosate application while all other treatments had less than 50% control at the field site near Desoto, IL. The Desoto site has been confirmed to contain glyphosate-resistant waterhemp.

This research demonstrates that an integrated approach to weed management that encompasses the application of appropriate residual herbicides near the period of weed emergence is necessary when managing multiple glyphosate-resistant weeds. In addition, the herbicides currently envisioned for use in Optimum GAT soybean did improve weed management compared with less diverse herbicide strategies.

YIELD OF HERBICIDE-RESISTANT SOYBEAN UNDER VARIOUS WEED CONTROL SYSTEMS. Molly M. Buckham and Christy L. Sprague, Graduate Research Assistant and Associate Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824

The recent commercialization of glufosinate-resistant (Liberty Link®) and second generation glyphosate-resistant (Roundup Ready 2 Yield®) soybean have provided new weed control opportunities and potentially higher yields for soybean growers. A field study was conducted in East Lansing and Richville, Michigan to evaluate weed control and compare yield of thirteen soybean varieties with four different herbicide-resistance characteristics under various weed management systems. The study was established as a split-plot design with four replications. Herbicide-resistance characteristic was the main plot factor and weed management system was the sub-plot factor. Soybeans were planted in 38-cm rows at 432,250 seeds per acre in mid-May at both locations. Since soybean isolines were not available, four varieties for each herbicide-resistance characteristic conventional, glyphosate-resistant (Roundup Ready®), and Liberty Link, as well as, a single Ready 2 Yield soybean variety were used in this study. The four weed management systems evaluated in this study included: 1) a preemergence (PRE) followed by postemergence (POST) herbicide program, 2) a two pass POST herbicide program, 3) a weed-free control, and 4) a nontreated control. Specific herbicides applied POST varied by the herbicide-resistance characteristic of the soybean varieties. The weed-free and nontreated controls were treated similarly for all thirteen soybean varieties. The two locations had very different weed populations. There was less than one weed per m^2 at Richville, and over 800 weeds per m^2 at East Lansing. Soybean injury was also different for the two locations from PRE herbicide applications. Soybean was injured from PRE applications at East Lansing only, due to over 10-cm of rain within two-weeks of application. Averaged across varieties, there was not a significant characteristic by weed management interaction for soybean yield at Richville. In fact, only herbicide-resistance characteristic was significant and yield was lowest for conventional soybean. However, at East Lansing there was a significant herbicide-resistance characteristic by weed management interaction for soybean yield. Similar to Richville, yields of the conventional soybean tended to be lower and the soybean varieties with the Roundup Ready 2 Yield and Liberty Link soybean characteristics had the highest yields across the different weed management systems.

EFFECT OF GLYPHOSATE AND FUNGICIDES ON SOYBEAN YIELD UNDER WEED-FREE CONDITIONS. Ryan S. Henry, Kiersten A. Wise, and William G. Johnson, Graduate Research Assistant, Assistant Professor, Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907

Growers can maximize yield by using management techniques that place a priority on plant health and sound agronomic practices. Strobilurin fungicides provide control of many foliar diseases and have been cited for non-fungicidal effects, such as improving a plant's health and delaying senescence in the fall. The objective of this experiment was to assess the impact of a strobilurin fungicide on soybean yield. Two glyphosate-resistant soybean cultivars were planted in Wanatah and West Lafayette, Indiana in 2009. Foliar treatments consisted of glyphosate, manganese, a strobilurin fungicide (pyraclostrobin), and an insecticide (lambda-cyhalothrin), applied alone or in various combinations. At West Lafayette there was a significant positive fungicide effect on soybean yield but not at Wanatah.

COMPETITION OF TRANSGENIC VOLUNTEER CORN WITH SOYBEAN AND THE IMPLICATIONS FOR WEED AND INSECT RESISTANCE MANAGEMENT. Paul T. Marquardt*, Christian H. Krupke, and William G. Johnson, Research Associate, Department of Botany and Plant Pathology, Assistant Professor, Department of Entomology, Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, 47907.

Glyphosate-resistant volunteer corn is a problematic weed in corn/soybean rotational systems. This issue is partially due to the increasing prevalence of stacking both glyphosate and insect-resistant (mainly Bt) traits into the same genetically-modified plant. Volunteer corn expressing Bt traits, which target the western corn rootworm (WCR), may potentially increase the Bt selection pressure on WCR populations. Volunteer corn can also compete with soybean, lowering yields. The objectives of this study were to determine how WCR emergence is affected by different densities of volunteer corn and to quantify the impact of volunteer corn on soybean growth and yield. Volunteer corn seed was hand-planted at densities ranging from 0.5 to 16 plants/m^2 within soybean plots. Densities were established at soybean planting and two weeks after planting to account for early and late emerging corn. WCR emergence was assessed using field emergence traps placed over individual corn plants in the 0.5 and 16 plants/m^2 plots. Data collected included the adult emergence of WCR, corn leaf area, dry weight (corn and soybean), and soybean yield. Twice as many adult WCR emerged from a single volunteer corn plant in 16 plants/m^2 plots compared to 0.5 plants/m^2 plots. Soybean yield reductions were 1516 kg/ha in the early planted 16 plants/m^2 plots. Yield reductions in 2008 and 2009 occurred when 2 and 4 plants/m^2, respectively, emerged at the same time as soybean. No soybean yield loss occurred when volunteer corn emerged after soybean. Our results show that controlling volunteer corn will not only prevent soybean yield loss, but it may decrease Bt selection pressure on WCR populations.

SIMULATED 2,4-D DRIFT ON ROUNDUP-READY SOYBEAN. Andrew P. Robinson, William G. Johnson, Jerry W. Keaton and David M. Simpson, Graduate Research Assistant and Professor, Department of Botany and Plant Pathology, Purdue University, 915 W. State St., West Lafayette, IN 47907, Dow AgroSciences, 9330 Zionsville Rd., Indianapolis, IN 46268.

New trait technologies incorporating 2,4-D tolerance in soybean will increase the use of 2,4-D causing a greater potential for drift. Our objective was to quantify crop injury and yield loss from 2,4-D drift on glyphosate-tolerant soybean. Ten rates (0, 0.112, 1.12, 11.2, 35, 70, 140, 280, 560 and 2240 g ae ha^{-1}) were applied at three timings (V2, V5 and R2) on Becks brand 342NRR soybean planted at Lafayette and Fowler, IN. Across application timings, crop injury was most to least injurious at 14>21>28>42 days after treatment. Yield components will be reported.

INTEGRATED MANAGEMENT STRATEGIES TO REDUCE WEED POPULATIONS IN PASTURES. Josh Tolson, J.D. Green, and William W. Witt, Research Assistant, Extension Professor, and Professor, Department of Plant & Soil Sciences, University of Kentucky, Lexington, Ky 40506.

Field studies were conducted on two grazed pastures on farms near Lawrenceburg and Richmond Kentucky during 2008-2009 to evaluate whether the management practices mowing, herbicide, and added fertility can reduce weed populations and improve pasture productivity. Each individual strategy plus combinations of mowing, herbicide, and fertility were evaluated using a three-way factorial experimental design. Initial weed populations were determined at each site in 2008 at time studies were established. Mowing was performed in July, followed by herbicide treatments in mid-August, and added fertility in September. Weed populations were measured the following summer and fall using 1 m^2 quadrants. Forage yields were also measured during 2009 for both desirable forage species and weed biomass. Harvested samples were separated into desirable forage grasses and clover, tall ironweed and other weeds present. Weed species evaluated were tall ironweed (*Vernonia altissima*), goldenrod (*Solidago* spp.), marshelder (*Iva ciliata*), and Philadelphia fleabane (*Erigeron philadelphicus*) in Lawrenceburg and tall ironweed, clammy groundcherry (*Physalis heterophylla*), and horsenettle (*Solanum carolinense*) in Richmond. Herbicide treatments at both locations provided 85 to 94 % reduction of tall ironweed 1 year after treatment. Goldenrod and marshelder populations were reduced approximately 100% and horsenettle was reduced 60% by treatments that included herbicides. All other treatments decreased weed populations with exception of the fertility treatment in Madison County. In general mowing alone and in combination with herbicide treatment and fertility had little effect on weed populations and forage yield at both locations. Although clover stands were reduced by herbicide treatments, overall forage yield was unchanged and weed biomass reduced. Added fertility increased yield of desirable forage species and had no effect on weed biomass.

EFFECT OF HERBICIDE APPLICATION TIMING ON SPINY AMARANTH CONTROL IN PASTURES. Meghan Edwards, J.D. Green and W.W. Witt, Research Assistant, Extension Professor, Professor, Department of Plant and Soil Sciences, University of Kentucky, Lexington, KY 40546.

Spiny amaranth is a problematic weed of heavily grazed pastures in Kentucky and surrounding states. The objectives were to evaluate spiny amaranth control when herbicides are applied before and after emergence. Spiny amaranth seed collected in 2008 were seeded in rows in the fall (November) and spring (March) in fields located in Lexington and Princeton, KY. Treatments consisted of five application dates and five herbicides plus an untreated control arranged in a split-split plot design with seeding date as the main plots. Treatment application dates arranged as sub plots were in November, March, April, May and June. Pendimethalin at 1.6 kg ai/ha, aminopyralid at 120 g ae/ha, aminocyclopyrachlor at 70 g ae/ha, dicamba at 0.56 kg ae/ha and 2,4-D at 1.1 kg ae/ha arranged as sub-sub plots were the five herbicides evaluated in this study. The following parameters were measured: fresh weight, plant height and percent visual control. Combined across locations pendimethalin applied in November, March and April before spiny amaranth emergence gave the best control and significantly reduced fresh weight biomass compared to other treatments. Aminopyralid applied in May after spiny amaranth emergence provided 70 percent visual control and significantly reduced plant height. Other herbicide treatments applied in May reduced spiny amaranth growth, but were less effective than aminopyralid. June applications of 2,4-D reduced plant height and provided 80 control. Fresh weight biomass and height was also reduced with dicamba, aminopyralid and aminocyclopyrachlor applied in June compared to pendimethalin and the untreated control.

TOLERANCE OF MISCANTHUS TO PREEMERGENCE AND POSTEMERGENCE HERBICIDES. Alexander J. Lindsey*, Wesley J. Everman and Calvin F. Glaspie, Graduate Research Assistant, Assistant Professor and Graduate Research Assistant, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Cellulosic ethanol production has been a focus in the continuing efforts to produce alternative fuel sources in the green economy. Miscanthus (*Miscanthus giganteus*), a non-native perennial grass, is slow to establish, but viable stands tend to be very prolific in biomass production, which indicates this species may be a good source for cellulosic ethanol production. A greenhouse study was conducted in East Lansing, MI to examine the tolerance of Miscanthus to PRE and POST herbicides. Seventeen PRE herbicides were applied at planting and evaluated at 28 and 35 days after emergence (DAE). Clomazone caused greatest injury, 5.4% and 6.0% at 28 DAE and 35 DAE, respectively, but this was not statistically different from the other PRE treatments (α=0.05). Eighteen POST herbicides were applied when Miscanthus was 30 cm in height and was evaluated at 7, 14, 21, and 28 days after treatment (DAT). At 28 DAT, Miscanthus treated with glyphosate, foramsulfuron, nicosulfuron, and imazamox exhibited 54, 32, 28, and 10% injury, respectively, which were statistically higher than all other treatments. Treatments of aminopyralid, dicamba + diflufenzopyr, and atrazine caused 0% injury at all ratings. Dry aboveground biomasses from glyphosate, foramsulfuron, nicosulfuron, and imazamox were 1.3, 1.4, 1.6, and 2.6 grams, respectively, which were significantly lower than all other treatments. Aminopyralid, halosulfuron, topraomezone, and dicamba + diflufenzopyr treatments resulted in the greatest dry aboveground biomass. Results from this study suggest the PRE herbicides examined have potential for use in field applications with minimal risk to Miscanthus establishment. POST herbicides examined in this study caused varying levels of injury but no mortality, which suggests a wide range of herbicides for potential use in Miscanthus stands. The survivability of Miscanthus when treated with PRE and POST herbicide indicates future control of this grass may be difficult.

V-10233 PERFORMANCE IN MIDWEST SOYBEAN FIELDS. Dawn E. Refsell, Eric J. Ott, Trevor M. Dale and John A. Pawlak, Field Market Development Specialists, Product Development Manager, Valent USA Corporation, Walnut Creek, CA 94596.

V-10233 is a new preemergence herbicide that will be registered in soybeans for the control of many broadleaf and grass weeds. Twenty-five trials were established throughout the soybean growing regions of the US, with 18 trials specifically located in the Midwest. Objectives of the trials were to determine weed control efficacy and crop tolerance of V-10233 at 0.143 and 0.178 lb ai/A in a Roundup Ready system compared to regional standards.

Preemergence (PRE) herbicides were applied at soybean planting. Evaluations were taken at 21 and 56 days after treatment (DAT). Treatments included; 1) POST glyphosate alone (0.77 lb ae/A) while the following PRE herbicide treatments included a POST glyphosate treatment (0.77 lb ae/A) 2) V-10233 (0.143 lb ai/A), 3) V-10233 (0.178 lb ai/A, 4) s-metolachlor + fomesafen (1.1 lb ai/A), 5) flumioxazin (0.064 lb ai/A) + cloransulam methyl (0.021 lb ai/A, 6) chlorimuron + tribenuron (0.0308 lb ai/A, 7) chlorimuron + flumioxazin + thifensulfuron (0.0774 lb ai/A), 8) sulfentrazone + cloransulam methyl (0.14 lb ai/A), and 9) imazethapyr + pendimethalin (0.091 lb ai/A).

Soybean injury was observed with all PRE treatments and ranged from 2 to 8% 21 DAT. No differences in injury were observed between the treated and untreated soybeans at 56 DAT. The PRE application of V-10233 at either rate provided equal to, or significantly better, control of redroot pigweed, waterhemp, Palmer amaranth, ivyleaf morningglory, common lambsquarters, velvetleaf, common ragweed, barnyardgrass and giant foxtail when compared to standards 28 and 56 DAT. Giant ragweed control with V-10233 was 50 and 70% at the 0.143 and 0.178 lb ai/A rates respectively, 28 DAT. This was less than the competitive products containing cloransulam methyl, but similar to other treatments included in the trial without cloransulam methyl. Differences in giant ragweed efficacy were not observed 56 DAT, all treatments provided greater than 90% control.

V10233 provides excellent residual control of broadleaf and grass weeds that are prominent throughout the Midwest soybean production region and will also be a beneficial tool for resistance management in the Roundup Ready system.

ENHANCING SAFLUFENACIL WITH ADJUVANTS AND TANK-MIX PARTNERS. Angela J. Kazmierczak, Richard K. Zollinger, and Jerry L. Ries, Research Associate, Professor, and Research Associate, Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050.

Saflufenacil was recently registered for preemergence weed control in several crops, including corn, soybean, wheat, field pea, and chickpea. Two field experiments were conducted to evaluate 1) herbicide programs in soybean and 2) adjuvant systems that enhance saflufenacil efficacy. An experiment was established at Buffalo, ND to evaluate herbicide programs. Early pre-plant treatments included glyphosate (870 g ae/ha) alone or with imazethapyr (696 g/ha), saflufenacil (25 g/ha) alone and with imazethapyr (95 g/ha), 2, 4-D ester (560 g/ha), and pendimethalin (1070 g/ha). A POST application of glyphosate (870 g ae/ha) was made to all plots. Treatments that included saflufenacil alone provided greater than 90% control of common lambsquarters, kochia, and biennial wormwood 19 and 35 d after PRE treatments (DAT). However, all treatments provided 99% control of shepherd's-purse, marshelder, redroot pigweed, and prostrate knotweed 35 DAT. An experiment established at Mapleton, ND evaluated salflufenacil (12.5 g/ha) which was applied with glyphosate (320 g ae/ha), ammonium sulfate (810 g/ha), and various adjuvants. POST applications were made to flax (*Linum usitatissimum*), quinoa (*Chenopodium quinoa*), tame buckwheat (*Fagopyrum esculentum*), amaranth (*Amaranthus hypochondriacus* L., x *Amaranthus hybrid)*, and kochia (*Kochia scoparia* (L.) Schrad.). In general, treatments that included a methylated seed oil (MSO) or a high surfactant oil concentrate (HSOC) provided the greatest control on all species with the exception of tame buckwheat where Succeed (MSO) provided 75 and 83% control, 7 and 21 DAT, respectively. At both ratings, treatments that included Persist Ultra (MSO) or Succeed provided greater than 68% control with the exception of kochia where 63% control was the highest rating determined.

PHYLOGENETIC ANALYSIS OF THE CHENOPODIUM COMPLEX. Sukhvinder Singh, Patrick J. Tranel, and A. Lane Rayburn, Graduate Research Assistant, Professor, and Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

A key step to efficient weed management is to correctly identify the weed species. Researchers have tried to systematically investigate common weed species, which has helped in proper weed identification and management. The *Chenopodium* genus is not a well-understood complex as there is considerable genetic and morphological variation within the species. The taxonomy of *Chenopodium* has been a major point of controversy, which mainly arises due to the phenotypic plasticity, parallel evolution, and hybridization within the genus. We used a phylogenetic approach to understand this complex genus, which includes some of the worst weeds of the Midwest. Our previous research indicated that some of the common weed species in *Chenopodium* not only have a close resemblance at the morphological level, but also at the level of DNA sequence. For example, *C. album, C. strictum,* and *C. berlandieri* accessions could not be consistently distinguished using sequence data from the internal transcribed spacer region of ribosomal DNA: these species were grouped within a common clade in the phylogenetic tree. In an effort to further resolve the phylogenetic tree, we used a cytogenetic approach. Our results from DNA content analysis suggest that *C. berlandieri* and *C. album* have significantly different genome sizes. Additionally, *C. strictum* has half the genome size of *C. album*. Thus, even though *C. strictum, C. berlandieri* and *C. album* share highly similar sequences among homologous genes, they can be differentiated based on genome size. These differences may be partially attributed to differences in ploidy levels, which currently is under further investigation.

ASIATIC DAYFLOWER SEEDLING EMERGENCE PATTERN IN ARTIFICIAL SEED BANKS.
José M. Gómez and Micheal D.K. Owen, Graduate Research Assistant and Professor, Department of Agronomy, Iowa State University, Ames, IA 50011.

Asiatic dayflower (*Commelina communis* L.) has become a problematic weed for Iowa farmers in recent years. The adoption of glyphosate-resistant (GR) crops combined with reliance on glyphosate as the principal tool for weed control have contributed to the establishment of Asiatic dayflower in agricultural fields. Field and laboratory research conducted in the past demonstrated that glyphosate does not control Asiatic dayflower. However, such research has not focused on the ecological and biological aspects that have contributed to the adaptation of Asiatic dayflower in GR crop systems. The objective of this research was to study Asiatic dayflower emergence patterns under conditions that are similar to those found in agricultural fields. Asiatic dayflower seeds were collected from Osceola (O) and Vinton (V), Iowa, and classified as large (L) and small (S) seeds. Two artificial seed banks were established in November 2008 at the Curtiss and Agronomy farms, near Ames, IA. Each site consisted of 24 PVC pipes buried in the ground and refilled with soil. Seedling emergence time was recorded during 2009. At the Agronomy Farm, emergence ranged from the day of year (DOY) 122 through 184 DOY. In contrast, seedling emergence at the Curtiss Farm ranged from 114 through 171 DOY. Seedling emergence at the Agronomy Farm was 65%, 85%, 44% and 48% for OS, OL, VS and VL seeds, respectively. Emergence at the Curtiss Farm was 74%, 65%, 55% and 61% for OS, OL, VS and VL seeds, respectively. Overall, results showed that Asiatic dayflower emergence ranged from late April to the middle of July, and not all seeds in the artificial seed bank germinated. These results also suggest that microclimate conditions affect the emergence of Asiatic dayflower. The extended emergence pattern of Asiatic dayflower may be attributed to the dimorphic seeds.

COMPARISON OF FIVE COMMON WATERHEMP (*AMARANTHUS RUDIS*) COHORTS: PLANT POPULATION DENSITY, FLOWERING DATE, AND CONTRIBUTION TO THE SOIL SEEDBANK. Chenxi Wu and Micheal D. K. Owen, Graduate Research Assistant and Professor, Department of Agronomy, Iowa State University, Ames, IA, 50011.

Common waterhemp is an increasingly problematic weed of agronomic systems throughout the Midwest United States. Common waterhemp seeds have a discontinuous emergence pattern and are able to germinate later in the season than many summer annual weed species, which makes common waterhemp difficult to manage, particularly in glyphosate-based crop systems. Our 2009 field study identified five cohorts of common waterhemp. Cohorts were established by counting and marking all seedlings emerged at a certain day in a 5m*5m quadrate at emergence intervals (May 22, May29, June 6, June22 and July 8) which were influenced by rainfall events. Seedling emergence was defined as full expansion of two cotyledons, and seedlings that emerged later within an established cohort area were removed. The population density, especially female plant density, of each cohort decreased as emergence occurred later in the summer with 4, 2, 2, 2 and 1 plants/m^2 in cohorts 1 through 5, respectively. Later-emerging cohorts transitioned from vegetative growth to reproductive growth faster and the time interval between emergence and flowering for each cohort varied from 27 to 54 days. However, there was no difference in reproductive time with all cohorts similar in time requirement of generating viable seeds. Common waterhemp was able to produce up to 5.6 (±1.3) $\times 10^5$ seeds/m^2. Later cohorts had reproductive outputs almost as high as earlier cohorts although later cohorts had a significantly smaller plant size. Knowledge of life history traits of cohorts, such as growth and reproduction would help in understanding the biology of common waterhemp and consequently help to develop guidelines for its control.

GROWTH ANALYSIS OF GLYPHOSATE RESISTANT GIANT RAGWEED BIOTYPES. Chad B. Brabham and William G. Johnson, Graduate Student and Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

The first giant ragweed (*Ambrosia trifida*) biotype in Indiana to evolve glyphosate resistance was discovered in 2005. However, it is unclear if glyphosate-resistance in giant ragweed has any fitness penalties. Our objective was to compare growth and reproductive characteristics of a glyphosate-resistant biotype to a susceptible giant ragweed biotype in the absence of glyphosate. Seeds of each biotype were hand planted on May 28th and June 1st, 2009 in West Lafayette, IN. Nine individuals of each biotype were harvested weekly for six weeks starting 15 days after planting. At each harvest, individual plants were measured for total height, width, node number, internode length, leaf area and dry weight of leaf biomass, stem and branches, main stem and overall above ground weight. The reproductive characteristics recorded were initial flowering date, total number of seeds produced and 100 seed weight. A glyphosate dose response analysis was conducted to determine the differences in GR_{50}'s and GR_{90}'s. There was a 1.42 fold difference in the GR_{90} of the resistant and susceptible biotypes in response to glyphosate. No obvious difference was observed between biotypes during vegetative stages. During reproduction resistant individuals flowered earlier and produced fewer seeds than the susceptible biotype. Further comparison of plant growth and functions will help determine if a fitness penalty is associated with glyphosate-resistance.

DIFFERENTIAL EXPRESSION OF GLYPHOSATE RESISTANCE DURING GIANT RAGWEED (*AMBROSIA TRIFIDA* L.) DEVELOPMENT. Renae R. Robertson, Burkhard Schulz, and Stephen C. Weller, Graduate Research Assistant, Assistant Professor, Professor, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907.

Giant ragweed (*Ambrosia trifida* L.) persists in disturbed areas and is a major weed problem in Midwestern US croplands where glyphosate is often used for its control. Glyphosate is the most widely used herbicide worldwide and kills weeds by inhibiting EPSP synthase, the key enzyme of the shikimate pathway. Repeated use of glyphosate in agronomic crop fields has selected for glyphosate resistant (R) giant ragweed plants in Indiana. This study investigated response of R populations compared to susceptible (S) populations of giant ragweed at various stages of plant development in greenhouse and field studies. R and S populations were treated at 5 different growth stages (1, 2, 3, 4, and 5 nodes). Each class was sprayed with glyphosate at 1x (0.7 kg/ha), 2X and 4X field rates and then evaluated for injury and plant biomass. We observed resistance in R populations compared to S populations at all plant sizes. Resistance was most pronounced at the 1X rate, but was observed at all rates in R populations. R plants showed initial injury at all glyphosate concentrations and developmental stages with onset of initial injury being faster in R populations than in S populations. However, R populations did not die and showed re-growth of new tissue at all rates while S populations ceased growth and died.

DETERMINATION OF WATER USE COEFFICIENTS OF COMMON LAMBSQUARTERS, FIELD PENNYCRESS AND HENBIT AS AFFECTED BY FRACTION TRANSPIRABLE SOIL WATER LEVEL AND GROWTH STAGE. Venkatarao Mannam, Mark L. Bernards, John L. Lindquist and Timothy J. Arkebauer, Graduate Research Assistant, Assistant Professor, Associate Professor and Associate professor, department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE 68588.

Water use efficiency is the ratio of total crop biomass (B) to water consumed, expressed as transpiration (T). The transpirable soil water is the amount of water available for plant growth and development and represents the difference between field capacity and the permanent wilting point. Water stress can be imposed by maintaining the soil water level of an experimental unit at a predetermined Fraction of Transpirable Soil Water (FTSW). A variable that defines the relationship between B and T is the crop water use coefficient (Kc). A crop water use coefficient can be calculated using cumulative transpiration, total dry biomass accumulation and seasonal day time vapor pressure deficit. Water use coefficient values are available for some crop species, but they are not available for most weed species. If we know the Kc value for a weed species we can then calculate how much it transpires for a given biomass. Little data is available describing the relationship of water stress or plant growth stage on the Kc. A greenhouse experiment was conducted at Lincoln, NE, in a completely randomized factorial design with 6 replications, 4 FTSW levels (0.3, 0.4, 0.7 and 1) and 2 harvesting times (first bloom and seed maturity) and was conducted twice for each species. Environmental conditions (temperature, relative humidity and photosynthetically active radiation) were recorded by a Watchdog model 2475 plant growth station. Three species (field pennycress, common lambsquarters and henbit) were planted individually in plastic pots filled with soil mixture and were thinned to one per pot. Once plants reached a predetermined growth stage, they were bagged at the base to eliminate evaporation from the soil and a syringe was inserted to allow access for daily watering. Daily transpiration was measured by weighing each pot, and water was added to bring the experimental unit back to the predetermined FTSW level. Cumulative transpiration was calculated by adding the daily transpiration rates. Plants were harvested either at first bloom or seed maturity. Leaf area, plant height and total dry biomass (shoots and roots) were recorded at the time of harvest. Kc values were higher at the time of flowering compared to seed maturity for a given level of water stress. In addition, as the FTSW increased from 0.3 to 1.0, Kc values decreased.

NITROGEN CONSUMPTION IN WEED SPECIES AS INFLUENCED BY APPLICATION RATE AND WEED REMOVAL TIMING. Laura E. Bast, Wesley J. Everman and Darryl D. Warncke, Graduate Research Assistant, Assistant Professor and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Nitrogen application rate and weed control timing are important components of integrated pest management and understanding their interaction is necessary to maximize economic return. A field study was established in 2009 in East Lansing, MI to quantify N consumption by giant foxtail, Powell amaranth, velvetleaf, common ragweed, and common lambsquarters and to evaluate N consumption as influenced by N application rate and weed removal timing. A split-plot, randomized complete block design consisted of four preplant nitrogen application rates (0, 67, 134, and 202 kg N/ha) as main plots and four weed removal timings as subplots. Weed removal timings were defined by weed heights of 5, 10, 15, and 20 cm tall. Fresh and dry weights were recorded at each weed removal timing from weed biomass samples collected from a 0.25 m^2 section of the plot. Additional samples of each weed species were collected and separated into root and shoot portions and analyzed for total N. Nitrogen content of giant foxtail, Powell amaranth, and velvetleaf shoots increased across fertility levels when weeds were 10, 15, and 20 cm. Root N content of Powell amaranth also increased with increasing N rate. Ragweed shoots and roots did not show as great a response to N rate, and N rate had no effect on N content of lambsquarters. For all species, 10 cm shoots tended to have the greatest percentages of N across fertility levels. Total N content was generally greater in shoots than in roots for all species regardless of N rate or removal timing, and for all species root N decreased with weed height. The results indicate the influence of N application rate and weed removal timing on N content varies among weed species, but corresponds with current weed control recommendations in Michigan to control weeds before they reach 10 cm in corn.

COMPETETIVE EFFECTS OF VOLUNTEER CORN *(ZEA MAYS* L.*)* IN CORN. Tye C. Shauck and Reid J. Smeda, Graduate Research Assistant and Associate Professor, Division of Plant Sciences University of Missouri, Columbia, MO 65211.

Volunteer corn *(Zea mays* L.*)* is considered a competitive weed that can significantly reduce yields when present in soybeans. However, research is limited on the impact of volunteer corn in corn. Field trials were established in Columbia and Novelty, Missouri in 2009 to determine the competitive effects of varying densities of volunteer corn on row corn leaf chlorophyll content, stalk diameter, and grain yield. Under no-till conditions, corn hybrids (69,190 seed per hectare) were sown on May 21 (Columbia) and 22 (Novelty) in 76 cm rows in 3 by 13.7 m plots in a randomized complete block design. Volunteer corn was planted randomly between the planted corn rows with a jab planter at densities ranging from 0 to 8 plants/m^2 at both locations. At the Columbia location, final volunteer corn stands were low, however, and ranged from 0 to 3.4 plants/m^2. After establishment, volunteer corn was allowed to compete season-long. Fifteen plants of row corn per plot were marked to collect growth data and estimate nitrogen content. Chlorophyll SPAD meter readings were taken as an indication of leaf nitrogen content and growth was estimated by recording stalk diameters at the end of the growing season.

At the highest volunteer corn plant density of 3.4 plants/m^2 at Columbia, leaf chlorophyll content decreased at the V6, V8, and VT growth stages by 7, 18, and 20%, respectively, compared to the untreated control without volunteer corn. At this same volunteer corn plant density at Novelty, leaf chlorophyll content decreased at the V6, V8, and VT growth stages by 12, 14, and 18%, respectively. At the highest volunteer corn plant density of 8 plants/m^2 at Novelty, leaf chlorophyll content was reduced by 17, 21, and 26%, respectively, compared to the untreated control. At densities of 3.4 volunteer corn plants/m^2, stalk diameters were reduced by 24% at Columbia and by 17% at Novelty compared to the untreated control. At Novelty, row corn grain yield was significantly reduced at a volunteer corn plant density as low as 0.5 plants/m^2 by 16.8%. Overall, row corn grain yields at Columbia and Novelty were reduced by 40 to 62% at volunteer corn plant densities of 3.4 plants/m^2. The results from these experiments indicate that volunteer corn is a competitive weed which can significantly reduce leaf chlorophyll content, stalk diameter, and grain yield of planted corn varieties.

WEED GROWTH IN CONVENTIONAL AND LOW-INPUT CROP ROTATIONS. Rachel B. Halbach and Robert G. Hartzler, Graduate Research Assistant and Professor, Department of Agronomy, Iowa State University, Ames, IA 50011.

A two year study was conducted in central Iowa to evaluate the effects of cropping systems on the growth of common waterhemp, common lambsquarters, giant ragweed, and velvetleaf. The cropping systems, established in 2002, were a corn-soybean rotation relying on convention inputs and a low-external input system based on a corn-soybean-oat/alfalfa-alfalfa rotation. Experiments were conducted during the soybean phase of the rotations. Since 2005, soybean in the diversified rotation had higher yields than soybean in the corn-soybean rotation. Our main objective was to determine if emergence, growth, and end-of-season biomass of the four weed species differed between a two-year and four-year crop rotation.

The first experiment evaluated emergence of the four species. Plots were field cultivated for seed bed preparation on 19 May 2008 and 12 May 2009. Glyphosate was applied to all plots on 30 June 2008 and 17 June 2009 at a rate of 0.84 kg ae ha^{-1}. Cumulative emergence for giant ragweed and common waterhemp was greater in the two year rotation than the four year rotation, but there were no differences in emergence between rotations for common lambsquarters or velvetleaf. Plots in 2009 in the conventional system had 60 more giant ragweed seedlings m^{-2} than those in the diversified system. Emergence of giant ragweed in 2008 was not different between the systems. Common waterhemp emergence in 2008 differed by 26 seedlings m^{-2}, with more emerging in the corn-soybean rotation. Seedlings emerged did not vary between systems in 2009 for common waterhemp.

A second study evaluated the growth and biomass production of the four weed species in the absence of control tactics. Seeds were planted immediately following soybean planting and when soybean was at the V2 stage. Height measured over the course of the growing season was not different between rotations for common waterhemp or common lambsquarters. Height of velvetleaf in the first cohort in the two year system on 20 Aug 2008 was 38.4 cm shorter than that in the four year system. No height difference was detected previous to that date or within the second cohort plants. Giant ragweed height in the first cohort was not different between systems, but plants in the second cohort growing in the conventional system were 57.1 cm taller than those in the diversified system on 2 Sept 2009. End of season biomass of giant ragweed in the first cohort was influenced by rotation, with the two year system producing only 75% of the four year system in 2008. Also in 2008, giant ragweed in the second cohort in the two year system produced less than 8% of that in the four year. In 2009, however, no difference existed between the systems in either planting. Velvetleaf in the first cohort in the conventional system also produced 38% less biomass than that in the low-input in 2008. Similar to giant ragweed, no difference was detected in velvetleaf biomass between the rotations in 2009. In both giant ragweed and velvetleaf, seeds sowed at the time of soybean planting produced 610.64 g and 70.97 g more biomass, respectively, than those planted at soybean V2 stage. Biomass of common waterhemp and common lambsquarters showed no differences in rotation or planting date.

ESTIMATED ECONOMIC LOSSES FROM EARLY WEED COMPETITION IN WISCONSIN CORN AND SOYBEAN FIELDS. Nathanael D. Fickett, David E. Stoltenberg, Chris M. Boerboom, and Clarissa M. Hammond, Graduate Student, Professor, Professor, University of Wisconsin, Madison, WI 53706 and Weed Scientist, Department of Agriculture, Trade, and Consumer Protection, Madison, WI 53708-8911.

A survey of Wisconsin agricultural professionals in 2007 indicated the majority believed over 75% of both corn and soybean fields in Wisconsin were being managed with postemergence glyphosate programs. Thus, the potential for significant yield loss due to early-season weed competition exists. To understand this potential, weed and crop characteristics were documented in Wisconsin corn and soybean fields through surveys taken immediately before postemergence herbicide applications. In 2008 and 2009, weed height and density by species were surveyed every 3 to 4 days until postemergence herbicide application in 48 and 45 corn fields and 30 and 40 soybean fields, respectively. Approximately five fields per county at least 5 km apart were randomly selected to be surveyed. For each field, a surveyor walked a horseshoe pattern through the field starting and ending at the field’s edge. Heights and densities of predominant weed species were estimated in 10 1-m^2 quadrats per field spaced at intervals of 30 paces. A modified version of WeedSOFT® was used to estimate crop yield losses based on the weed population characteristics.

Corn fields had average weed heights of 15 and 14 cm and weed densities of 102 and 93 plants/m^2 in 2008 and 2009, respectively. Soybean fields had average weed heights of 21 and 18 cm and weed densities of 107 and 98 plants/m^2, in 2008 and 2009, respectively. The early season weed growth and competition measured in the corn fields was estimated to cause a 4.4 and 4.8% yield loss in 2008 and 2009, respectively. In soybean fields, the average estimated yield loss from weed competition was 9.3 and 3.1% in 2008 and 2009, respectively.

The risk of crop yield loss due to early season weed competition can be reduced through the application of preemergence herbicides. In 12 on-farm soybean trials in 2009, the efficacy of a reduced rate of a preemergence herbicide in soybean was determined by comparing weed control using postemergence glyphosate weed control from sulfentrazone plus cloransulam at 130 g ai/ha plus 17 g ai/ha followed by glyphosate. Each trial used three replications and plots approximately 7 ha in size. Weed density and height by species were measured before the whole trial was treated with glyphosate. The preemergence herbicide reduced both broadleaf and grass weed density and height compared to the glyphosate treatment, but not in each field. Overall, the average density of broadleaf and grass weeds was reduced by 66 and 50% and heights were reduced by 20 and 30%, respectively.

Glyphosate has enabled growers to obtain highly effective weed control even if larger weeds are treated or if applications are made later in the season. However, this research suggests that the hidden cost from late weed control and early season crop-weed competition is resulting in corn and soybean yield losses in Wisconsin. Economically viable means of reducing the risk of yield loss need to be evaluated and adopted where feasible.

TILLAGE-INDUCED MULTIPLE SEASON DEGRADATION OF WOLF SPIDER (ARANEAE: LYCOSIDAE) HABITAT. Randall S. Currie, Holly N. Davis, Lawrent L. Buschman, Norman L. Klocke, and B. Wade French, Associate Professor, Kansas State University, SW Research-Extension Center, Garden City, KS 67846, Insect Diagnostician and Professor, Department of Entomology, Kansas State University, Manhattan, KS 66506, Professor, SW Research-Extension Center, Kansas State University, Garden City, KS 67846, Research Entomologist, USDA, Brookings, SD 57006.

From 1998 to 2004, a balanced factorial study of three levels of atrazine with and without a killed winter wheat cover crop was imposed on the same plots for 3 yr at each of three locations as described in Currie and Klocke (2005). After that study was completed, half of each plot was disked twice to produce 12 unique management histories in each of 5 replicates during the fallow phase that lasted from 18 to 22 months after completion of the original study. Ground-dwelling arthropods were collected in fall traps as described in Davis et al. (2009). Although more than 7,000 arthropods from 20 genera were collected and classified, only wolf spider (Araneae: Lycosidae) results are presented here. At Location 1, significantly higher numbers of wolf spiders were found in subplots managed as no-till and in plots with residues from the history of a cover crop. There was a two-way interaction between tillage and prior weed density. Wolf spiders were most common in no-till subplots with a history of high weed densities created by the lack of herbicide use. Differences between tillage treatments decreased under lower weed densities induced by herbicide use. Significantly more wolf spiders were collected in no-till subplots and plots with a cover crop history than in tilled subplots and in plots without a cover crop history. Herbicide-induced weed density histories did not affect wolf spider numbers at Location 1. At Location 2, there were no significant interactions between the three treatment factors and no differences in the number of wolf spiders found in the three herbicide-induced weed density histories. There were significantly higher numbers of wolf spiders in no-till subplots and in plots with a cover crop history at this location. At Location 3, there were no significant interactions between the three treatment factors. Clearly, tillage damaged wolf spider habitat, and the history of cover crop use was still positively affecting wolf spider habitat more than a year after the practice was stopped.

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IMPACT OF AGRICULTURAL PRACTICES ON FUNGAL-ASSOCIATED DECAY OF GIANT RAGWEED SEED IN SOIL. Xianhui Fu, Joanne Chee-Sanford, Martin M. Williams II and Adam S. Davis, Ph.D student, Department of Natural Resources and Environmental Sciences, University of Illinois, Urbana, IL 61801, Environmental Microbiologist, United States Department of Agriculture-Agricultural Research Service, Affiliate, Department of Natural Resources and Environmental Sciences, University of Illinois, Affiliate, Department of Crop Sciences, University of Illinois, Urbana, IL 61801, Ecologist, United States Department of Agriculture-Agricultural Research Service, Assistant Professor, Department of Crop Sciences, University of Illinois, Adjunct Professor, Natural Resources and Environmental Sciences, University of Illinois, Urbana, IL 61801, and Ecologist, United States Department of Agriculture-Agricultural Research Service, Assistant Professor, Crop Sciences, University of Illinois, Faculty member, Program in Ecology and Evolutionary Biology, University of Illinois, Affiliate, Natural Resources and Environmental Sciences, University of Illinois, Urbana, IL61801.

Seed-banks are the greatest source of annual weed emergence in cropland. Reducing seed-bank persistence is an important goal of weed management, however little is known about seed-bank dynamics and factors that can affect seed fate in soil. Seed burial studies, along with fungicide treatment, previously provided evidence for fungi as a seed mortality factor in soil. While our recent research revealed characteristics of fungal communities on surfaces of decayed seeds of giant ragweed following burial in soil, knowledge of how fungi-seed interactions are affected by agricultural practices is still lacking. Artificial seed-banks were established under conventional-, reduced-, and no-tillage fields in both corn and soybean crops to examine the effects of tillage, crop, burial depth and time, and related environmental factors on fungal-mediated seed decay of giant ragweed from Nov. 2006 to Nov. 2007. PCR-based ARISA was used to characterize the fungal communities associated with both soil and seed specimens. Our results showed that the seed decay rate changed over burial time, with generally higher rates obtained during the time period from May to June, corresponding to the start of the crop growing season. The temporal and spatial dynamics of seed decay rates in soils under conventional and reduced tillage were similar regardless of current crop, and these differed significantly from the dynamics obtained under no-tillage. Large variations of seed decay rate among burial depths were also detected in most tillage and current crop combinations except in no-tillage under corn from May to June. Multidimensional scaling (MDS) analysis showed that fungal community structure in soils or on seed surfaces changed over time. The tillage type and burial depth significantly influenced the fungal community structures in soil and on seed surfaces. This research increases our understanding of seed-bank dynamics and factors that can affect fungal - associated weed seed mortality in soil. Such information will be useful for developing integrated weed management strategies.

PREPONDERANCE OF THE PROTOPORPHYRINOGEN OXIDASE GLYCINE DELETION IN WATERHEMP RESISTANT TO PPO INHIBITORS. Kate A. Thinglum, Chance W. Riggins, Patrick J. Tranel, Kevin W. Bradley, and Kassim Al-Khatib, Graduate Research Assistant, Post Doctoral Research Assistant, and Professor, University of Illinois, Urbana, IL 61801, Associate Professor, University of Missouri, Columbia, MO 65211, and Professor, Kansas State University, Manhattan, KS 66506.

Research was conducted to determine if all waterhemp populations containing resistance to PPO-inhibiting herbicides have the same mechanism of resistance and to determine if the allele conferring resistance has been independently selected. Four resistant populations (two from Missouri and one each from Illinois and Kansas) and three sensitive populations (one from each of the above three states) were used in the study. Greenhouse dose-response experiments with the PPO-inhibitor lactofen indicated that the different resistant populations contained moderately different levels of resistance. However, results from screening multiple plants from each population at a single rate of lactofen suggested that these differences likely were due to different frequencies of resistant plants among populations, rather than differences in the absolute biotypic levels of resistance. Plants were assayed for the presence or absence of a deletion (ΔG210) in the *PPX2* gene that was previously shown to confer resistance to PPO-inhibiting herbicides in waterhemp. The presence of this deletion was highly associated with resistance in each of the resistant populations. To address the question of independent selection of the resistance allele, a region of the *PPX2* gene was sequenced and resulting sequences were aligned and organized into a phylogenetic tree. Resistance alleles did not cluster together, suggesting the ΔG210 mutation has been independently selected. These results add to a growing body of evidence indicating that the ΔG210 mutation – despite being an unusual resistance mutation – is the primary (and thus far, only) mechanism of resistance to PPO inhibitors in waterhemp.

MOLECULAR MODELING AND BIOCHEMICAL EFFECTS OF A GLYCINE DELETION IN WATERHEMP PROTOPORPHYRINOGEN OXIDASE. Patrick J. Tranel, Ryan M. Lee, Franck E. Dayan, Stephen O. Duke, Pankaj R. Daga, and Robert J. Doerksen, Professor and Postdoctoral Research Assistant, Department of Crop Sciences, University of Illinois, Urbana, IL 61801, Research Leader and Research Plant Physiologist, USDA-ARS National Center for Natural Products Research, University, MS 38677, Graduate Research Assistant and Assistant Professor, Department of Medicinal Chemistry, University of Mississippi, University, MS 38677.

Resistance to PPO-inhibiting herbicides in waterhemp previously was determined to be due to a deletion of a glycine codon (ΔG210) in the *PPX2* gene. Despite being an unusual mutation, it has been identified in multiple waterhemp populations with resistance to these herbicides and, in fact, is the only mechanism thus far identified for resistance to PPO inhibitors in waterhemp. Biochemical experiments with mutant and wild-type enzyme were conducted to determine the effects of the ΔG210 mutation on enzyme kinetics. Consistent with whole-plant data, the mutant enzyme conferred an approximately 200-fold level of resistance to PPO inhibitors in vitro. Although the mutation did not affect binding affinity for the substrate, it decreased the catalytic efficiency approximately 10-fold. Unexpectedly, the mutation also changed herbicidal inhibition from competitive to mixed-type inhibition. Molecular modeling and molecular dynamics simulation revealed that the ΔG210 mutation destabilized the capping region of an alpha helix that is in close proximity to the active site. This was predicted to cause an increase in the distance between bound substrate and the isoalloxazine ring of the FAD cofactor, which could account for the decreased reaction rate, and an increase in the size of the active site, which could account for the change to mixed-type – rather than strictly competitive – inhibition. These results provide further insights as to why the ΔG210 mutation appears to be the most favored evolutionary path to achieve resistance to PPO inhibitors in waterhemp.

AN ALTERNATIVE TO THE GLYCINE DELETION: WHY R98L WAS SELECTED IN COMMON RAGWEED PROTOPORPHYRINOGEN OXIDASE. Stephanie L. Rousonelos, Ryan M. Lee, and Patrick J. Tranel, Graduate Research Assistant, Postdoctoral Research Assistant, and Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61820.

Research was performed to elucidate the mechanism of resistance to PPO-inhibiting herbicides in a common ragweed biotype from Delaware. A point mutation was identified in the *PPX2* gene that causes an amino acid substitution of Arg to Leu. This particular amino acid residue has been previously established as highly conserved throughout most species and plays a vital role in binding the enzyme substrate. Confirmation that this mutation was responsible for resistance was obtained by genetic complementation of an *Escherichia coli* PPO mutant and subsequent growth assays in the presence of varying concentrations of lactofen. The resistance-conferring mutation in common ragweed *PPX2* is different than that selected in the corresponding waterhemp gene, which was a deletion of a glycine codon (ΔG210). Inspection of the DNA sequences at each mutation location in the genes of the two species provided an explanation as to why the two different mutations were selected. In the case of waterhemp, a tri-nucleotide repeat likely enabled the ΔG210 mutation, whereas such a repeat was not present at the homologous location of common ragweed *PPX2*. For common ragweed, the *PPX2* mutation of an Arg to Leu codon required a single nucleotide change; in waterhemp *PPX2* however, two nucleotide changes would be required to obtain the same amino acid change. These findings provide the opportunity to predict what mutations might be selected as resistance mechanisms to PPO inhibitors in other weed species.

ANALYSIS OF HERBICIDE INTERACTIONS USING FLUORESCENCE MEASUREMENTS. Rachel K. Bethke, Donald Penner, William T. Molin. Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI, USDA-ARS, Stoneville, MS.

Tank-mixing of herbicides with different chemistries provides the opportunity to control herbicide resistant weeds. Specifically, the opportunity may exist to control glyphosate and sulfonylurea resistant weeds with glufosinate. The combination of glyphosate or glufosinate and chlorimuron and of glyphosate and glufosinate in a tank mix has the potential to cause unexpected interactions. Interactions between glyphosate, glufosinate and chlorimuron have been observed in the greenhouse and the field. The objective of this study was to evaluate the combinations of glyphosate, glufosinate and chlorimuron on three annual weeds; giant foxtail, common lambsquarters, velvetleaf and the perennial weed, Canada thistle using fluorescence. Fast acting herbicides like glufosinate cause rapid inhibition of photosynthesis which is observable through fluorescence measurements before injury may be visible. When applied alone or in combination with these herbicides, glufosinate caused a rapid decrease in Fm, Fv and Fv/Fm, due to the rapid quenching of chlorophyll fluorescence. Changes in the maximum capacity for photochemical quenching (Fv) are observable within 4 HAT when glufosinate is applied alone or in combination, indicative of the rapid breakdown of the plants protective non-photochemical photosynthetic systems. With glyphosate alone and in combination with chlorimuron, changes in Fv are observable within 24 HAT whereas chlorimuron alone shows no observable changes until 72 HAT. The fast action of glufosinate on the photosynthetic system may limit translocation and expression of the activity of glyphosate and chlorimuron and results indicate that the combinations of glufosinate with glyphosate and chlorimuron may be antagonistic.

GLYPHOSATE RESISTANCE IN WATERHEMP: INHERITANCE AND EPSPS COPY NUMBER. Michael S. Bell, Patrick J. Tranel, and Chance W. Riggins, Graduate Research Assistant, Professor and Postdoctoral Research Assistant, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

The inheritance of glyphosate resistance was investigated in a glyphosate-resistant (R) waterhemp population (MO1) from Missouri. The MO1 population was crossed with a glyphosate-susceptible (S) population (ACR) to create F_1s. Reciprocal crosses were utilized to determine whether glyphosate resistance was maternally or nuclear inherited. F_1 lines were screened with glyphosate in the greenhouse, and a range of phenotypes from R to S were observed, with no apparent dependence on the direction of the cross. Thus, glyphosate resistance appears to be a nuclear inherited trait. F_2s were created by crossing F_1 plants, and F_2 lines were screened for glyphosate resistance. Again, a range of phenotypes from R to S were observed in these F_2 lines. BC_s lines were also created by crossing F_1 plants with ACR, with reciprocal crosses again utilized. The progeny were screened with glyphosate and demonstrated a range of phenotypes from intermediate to S. An attempt was also made to create a homozygous glyphosate-resistant line by utilizing clones. Cloning of plants enabled multiple crosses for each plant, including a testcross to the S biotype. Screening of testcross progeny for glyphosate resistance potentially could enable discrimination of homozygous from heterozygous parents. Unexpectedly, however, testcross progeny did not exhibit segregation ratios consistent with glyphosate resistance being a single gene trait. Based on experiments conducted on palmer amaranth showing that R palmer contained up to an 80-fold increase in EPSPS copy number, qPCR was performed on waterhemp from the F_1, F_2 and MO1 lines to test whether the same resistance mechanism was present in waterhemp. MO1 showed a four-fold increase in EPSPS copy number as compared with ACR. Investigation of F_1s revealed a range of copy number from that of ACR to even more than that of MO1. Preliminary results suggest that increased copy number alone does not necessarily confer resistance to glyphosate. All resistant plants had increased copy number, but not all plants with increased copy number were resistant. This indicates that, in addition to increased EPSPS copy number, another factor is necessary to confer glyphosate resistance.

MANAGING GLYPHOSATE-RESISTANT HORSEWEED WITH POSTEMERGENCE APPLICATIONS OF GLYPHOSATE AND 2,4-D. Greg R. Kruger, Vince M. Davis, Stephen C. Weller, and William G. Johnson, Graduate Research Assistant, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47904, Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801, Professor, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47904, Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47904.

A natural-emerging glyphosate-resistant horseweed population was identified at the Southeastern Purdue Agricultural Center. The purpose of this study was to characterize the response of glyphosate and 2,4-D treatments on a glyphosate-resistant horseweed population. A field study was designed with a factorial arrangement with six rates of glyphosate (0, 0.14, 0.28, 0.56, 1.12, and 2.24 kg ae/ha) and six rates of 2,4-D amine (0, 0.07, 0.14, 0.28, 0.56, and 1.12 kg ae/ha) in all combinations for four different horseweed sizes (0 to 7, 7 to 15, 15 to 30, and greater than 30 cm tall plants). The experiment was set up in a randomized complete block design with four replications in both 2008 and 2009. Plants were visually evaluated and harvested at 28 days after treatment. Neither 2.24 kg/ha of glyphosate nor 1.12 kg/ha of 2,4-D alone provided complete control of the horseweed population. Plants greater than 15 cm tall at the time of application were more tolerant to the herbicide treatments than plants less than 15 cm tall. However, tank mixtures on horseweed plants less than 15 cm tall were 2.5 times more likely to be antagonistic than synergistic while tank mixtures on horseweed plants greater than 15 cm tall were four times more likely to be synergistic than antagonistic. Tank mixtures had a predominantly additive response regardless of plant size. Tank mixtures of glyphosate plus at least 560 g/ha of 2,4-D provided greater than 80% of glyphosate-resistant horseweed.

EFFECT OF GROWTH MEDIA ON COMMON LAMBSQUARTERS AND GIANT RAGWEED BIOTYPES RESPONSE TO GLYPHOSATE. Jessica R. Schafer, Andrew M. Westhoven, Greg R. Kruger, Vince M. Davis, Steven G. Hallett, and William G. Johnson. Graduate Research Assistant, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907, Agronomist, AgriGold, West Lafayette, IN 47907, Graduate Research Assistant, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907, Assistant Professor, Department of Crop Science, University of Illinois, Urbana, IL 61801, Associate Professor, and Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

A well recorded but rarely cited phenomenon is observed in plants treated with glyphosate: plants grown in unsterile media suffer more damage following a glyphosate application than those grown in sterile soil. This reveals that glyphosate predisposes plants to disease and this secondary mode of action of the herbicide is important. In particular, conducting greenhouse studies in pathogen free potting soil may obscure an important component of the mode of action of glyphosate. Research conducted to investigate the activity of glyphosate has provided differing results when performed in different soil media. The objective of this study was to determine the effect of soil microbes on the response of sensitive and insensitive common lambsquarters (*Chenopodium album*) and giant ragweed (*Ambrosia trifida*) biotypes in response to glyphosate. We treated sensitive and insensitive biotypes grown in sterile and unsterile media to a range of glyphosate rates. Plants grown in unsterile soils had the greatest dry weight reduction across all rates. Both sensitive and insensitive biotypes were able to survive in sterile soil at 3.36 kg ae/ha while plants grown in unsterile soil did not survive. Interestingly, for each biotype, the impact of glyphosate was greater in the unsterile soils than the sterile. Our findings confirm that the insensitive biotype of each weed was more sensitive to glyphosate in unsterile soil, than the sensitive biotype in sterile soil. Soil microbes play an important role in the mode of action of glyphosate. Thus, it is possible that the evolution of resistance to glyphosate may stem not only from the resistance to the herbicide itself, but also resistance to soil microbes. Further research will investigate whether or not the insensitive biotypes of common lambsquarters and giant ragweed studied here exhibit elevated levels of resistance to soil microbes.

A well recorded but rarely cited phenomenon is observed in plants treated with glyphosate: plants grown in sterile media suffer much less damage following a glyphosate application than ones grown in field soil. Screening studies for glyphosate resistance in common lambsquarters (*Chenopodium album*) and giant ragweed (*Ambrosia trifida*) biotypes has revealed inconsistent results in greenhouse and field studies, where soil media differs. The objective of this study was to determine the effect of various growth media on the response of resistant and susceptible common lambsquarters and giant ragweed biotypes to glyphosate. Biotypes were grown in three different soil medias: commercial potting mix, 1:1 sand-bark mix, and field soil, differing in soil microbe communities. Glyphosate treatments included 0.84 and 3.36 kg ae/ha. Current experiments being conducted with biotypes grown in field soil, and the same soil that had been sterilized by gamma irradiation, treated with 6 different rates of glyphosate. Plants grown in potting and sterile soil had the lowest amount of dry weight reduction, while plants grown in field soil had the highest amount of dry weight reduction. Both susceptible and resistant biotypes were able to survive in sterile soil at a 4-fold rate, while plants grown in unsterile were killed. From these results, it is apparent that the activity of glyphosate was decreased in the presence of soil microbes in both susceptible and resistant biotypes of common lambsquarters and giant ragweed. Concluding that soil microbes play a role on the mode of action of glyphosate, and may reveal insight to the mechanism of glyphosate resistance.

ERADICATION STUDIES IN MISCANTHUS X GIGANTEUS. Eric K. Anderson, Thomas B. Voigt, Germán A. Bollero, Aaron G. Hager, Graduate Research Assistant, Associate Professor, Professor, and Associate Professor, Department of Crop Science, University of Illinois at Urbana-Champaign, Urbana, IL 61801.

Miscanthus x *giganteus* (Mxg) is a perennial C4 grass currently being investigated in the U.S. as a potential bioenergy feedstock. It is a sterile triploid hybrid with an extensive rhizome mass and high biomass potential. Adoption of a non-native perennial species by U.S. growers could be enhanced with established methods of eradication. Field experiments were conducted from 2007 to 2009 to evaluate several methods of controlling Mxg. An experiment involving fall and spring applications of glyphosate (1730 g ae/ha) following a late summer harvest of above-ground biomass showed that fall, spring, and fall + spring applications significantly reduced above-ground biomass the summer following spring treatments. A second experiment evaluating shallow spring tillage and glyphosate (2530 g ae/ha) treatments showed that tillage in combination with one or two glyphosate applications provided the highest level of control in the same growing season. However, substantial regrowth occurred the following season. A third experiment evaluated the feasibility of planting glyphosate-resistant soybean directly into a mature stand of Mxg without significant yield reduction. Results showed that, compared with a weed-free control, soybean yield was not reduced when one (1740 g ae/ha) or two sequential (1740 g ae/ha + 790 g ae/ha) glyphosate applications were made in-crop. One soybean field was subsequently rotated to glyphosate-resistant corn in 2009 with the same treatment scheme. Corn yield results were similar to those from the soybean experiment. The Mxg population was also reduced from the previous season, but complete eradication was not achieved. These experiments indicate that tillage and glyphosate can control a mature Mxg stand, but treatments will need to be employed for at least two growing seasons for complete eradication.

INTEGRATED MANAGEMENT OF *PHRAGMITES AUSTRALIS* (COMMON REED) ALONG THE PLATTE RIVER. Ryan E. Rapp* and Stevan Z. Knezevic, Graduate Student and Associate Professor, Department of Agronomy and Horticulture, University of Nebraska, Concord, NE 68728.

Phragmites (*Phragmites sp.*), also known as common reed, is a major problem weed occurring in the Nebraska's wetlands. The native (*Phragmites australis* subsp. *americanus*) and non-native (*Phragmites australis* subsp. australis) can be found along the Platte river from Wyoming to eastern Nebraska and expanding. Therefore a series of 12 experiments were initiated at 3 locations in 2008 with the objective to determine integrated approach for managing Phragmites *australis* along the Platte River based on herbicides, mowing and disking. Each experiment was arranged in a randomized complete block design with 3 replications. Visual ratings were done to determine level of control. ANOVA of plant growth responses to the control methods was performed using PROC GLM to test data normality and significance ($P < 0.05$) of the year, location, and replication. Treatment differences were based on an LSD test. Phragmites control was highest utilizing herbicide in combination with mechanical treatment of either mowing or disking. Herbicide alone provided higher control than disking alone or mowing alone. Mowing treatments combined with herbicide (120 DAT) were significantly better than mowing alone. Mowing alone provided short term control with almost immediate regrowth of Phragmites. Disking alone provided higher control than mowing alone resulting in lower plant populations (30 DAT). Treatments with herbicide and either mechanical treatment have provided a high level of control (>90%). All herbicide alone or combination with mechanical methods had control ratings 90% or higher. rappr@huskers.unl.edu

FIELD PERFORMANCE OF FLAMING HOOD VS OPEN TORCH. Chris A. Bruening*, George Gogos, Robert Leskovsek, Santiago M. Ulloa and Stevan Z. Knezevic. Graduate Student, Professor, University of Nebraska, Lincoln, NE 68588; Graduate Student, Agricultural Institute of Slovenia, Ljubljana, Slovenia; Graduate Research Assistant, Assistant Professor, Haskell Agricultural Laboratory, University of Nebraska, Concord, NE 68728.

The ultimate goal of any weed control treatment is to obtain the desired level of weed control at a reasonable cost, and that is no different for the thermal weed control method of flaming. A flaming hood, which contains and concentrates the heat produced from the combustion of propane, can help to reach that goal. There have been several flaming equipment designs in the past that have utilized a hood of some type. Our team designed a new hood that is simple in operation and fabrication, yet very effective in maintaining flame stability and in containing the heat. Two field studies were conducted in 2009 at the Haskell Ag Lab of UNL, with the objective to compare the new hood design against a common open torch. Five propane rates (0, 19, 29, 41, and 56 kg/ha) were used, and flaming treatments were applied utilizing an ATV mounted flamer moving at a constant speed of 4.8 km/h (3 mph). Each study was arranged in a randomized complete block design with three replications. A total of six plant species were used in the study: field corn, soybean, velvetleaf (*Abutilon theophrasti*), ivyleaf morningglory (*Ipomoea hederacea*), common ragweed (*Ambrosia artemisiifolia*), and green foxtail (*Setaria viridis*). The response of each species to propane flaming was evaluated in terms of visual injury ratings (1, 7, and 14 DAT). The new hood design offered the greatest benefit in control of common ragweed, resulting in ED_{90} (90% injury) values of 46 kg/ha and 6 kg/ha for the open torch and flaming hood, respectively. On average, the new hood design decreased the ED_{90} values by 50%. (ggogos1@unl.edu)

CHRISTMAS TREE AND WEED RESPONSE TO HERBICIDE APPLICATION IN FIRST AND SECOND YEAR FRASER FIR. Linglong Wei, Bernard H. Zandstra, Rodney V. Tocco and Chad M. Herrmann. Graduate Research Assistant, Professor, Research Assistant and Graduate Research Assistant. Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325.

Recently established Christmas trees are very susceptible to weed competition and herbicide injury. Traditional herbicide programs for transplants, as well as established trees, have included atrazine, simazine and oryzalin. These herbicides in combinations provide moderate to good weed control for 6-8 weeks, and relatively good crop safety. However, continued use of PS II inhibitors has resulted in several herbicide-resistant species and a preponderance of weeds which are naturally herbicide tolerant. On very light soils, where many of the Christmas trees are grown, these herbicides may stunt new transplants.

Experiments were conducted in 2008 and 2009 to test and compare new and old herbicides for post-transplant application in Fraser Fir (FF). Experiments were established in 2008 at Horton, MI on 1 year old FF, and at Gobles MI on new transplants. Westar, a premix containing 68.6% hexazinone and 6.5% sulfometuron-methyl, was applied at 4, 6, 8, 10 or 12 oz/acre in spring 2008 and 2009. Other treatments included flumioxazin at 0.255 lb/a, simazine at 4 lb/a plus oryzalin at 3 lb/a plus paraquat dichloride at 1 lb/a, and pronamide at 2 lb/a plus oxyfluorfen at 1 lb/a. The plots were rated for weed control and crop tolerance during the growing seasons, and leader length (LL), total height, and stem diameter were measured in the fall of 2008 and 2009.

In the Gobles trial in fall 2008, there were no differences in LL or total height between treatments. FF treated with Westar at 12 oz/a had reduced stem diameter. In fall of 2009, FF treated with flumioxazin had the longest LL, and that treatment was not different from simazine + oryzalin + paraquat dichloride, pronamide + oxyfluorfen, or the untreated control.

In the Horton trial in fall 2008, there was no difference in total height between treatments. FF treated with Westar at 10 oz/a had reduced LL. All other treatments were not different from the untreated control. There was no difference in stem diameter. In fall 2009, Westar treatments had reduced LL compared to flumioxazin and the untreated control. Only trees treated with simazine + oryzalin + paraquat dichloride had reduced diameter. Westar (all rates) and flumioxazin provided good to excellent weed control through the season, except that horseweed emerged in mid season in flumioxazin plots. The treatments other than Westar and flumioxazin were not as effective in overall weed control. It appears that Westar at low rates and flumioxazin are good alternatives to traditional herbicides for Christmas tree weed control.

EFFECT OF ADJUVANT, SPRAY VOLUME, AND RATE ON DRY BEAN DESICCATION WITH SAFLUFENACIL. Jordan L. Hoefing*, Brian M. Jenks, Gary P. Willoughby, Richard K. Zollinger, Jerry L. Ries, and Robert G. Wilson, Research Specialist, Weed Scientist, and Research Specialist, North Dakota State University, Minot, ND 58701, Professor and Research Specialist, North Dakota State University, Fargo, ND 58108, Professor, University of Nebraska, Scottsbluff, NE 69361.

Saflufenacil is an experimental broadleaf herbicide that has potential for use as a dry bean desiccant. Two studies were conducted at Minot, ND, Fargo, ND, and Scottsbluff, NE in 2009 to evaluate 1) the effects of adjuvant and spray volume and 2) the effect of rate on dry bean desiccation with saflufenacil. The target application timing for all treatments was when 80% of the pods had started to turn from green to yellow.

Study 1: Treatments at all three locations included saflufenacil at 25 g/ha plus non-ionic surfactant (NIS) at 0.25% v/v, crop oil concentrate (COC) at 1% v/v, or methylated seed oil (MSO) at 1% v/v. These three treatments were applied with AMS (17 lb/100 gal) at 10 gal/A. To evaluate the effect of spray volume, saflufenacil (25 g/ha) plus MSO and AMS was applied at 47 L/ha.

Study 2: Treatments at all three locations included saflufenacil at 18, 25, and 50 g/ha plus MSO and AMS at 1.0% v/v and 17 lb/100 gal, respectively; glyphosate (840 g/ha) plus MSO and AMS; glyphosate tank mixed with saflufenacil (18 g/ha) plus MSO and AMS; flumioxazin (54 g/ha) plus MSO; and carfentrazone (44 g/ha) plus MSO and AMS. Scottsbluff also included carfentrazone plus MSO and AMS; carfentrazone tank mixed with glyphosate plus MSO and AMS; paraquat (560 g/ha) plus NIS; and glyphosate plus AMS. All treatments at Minot and Fargo were applied at 94 L/ha, while treatments at Scottsbluff were applied at 187 L/ha.

At Minot, treatments were evaluated visually for leaf, stem, and pod desiccation 4, 7, 10, and 14 DAT. At Fargo, visual desiccation was evaluated at 7, 10, and 14 DAT. At Scottsbluff, visual desiccation was evaluated at 5 and 10 DAT. In addition, actual plant moisture was determined at Minot and Scottsbluff by sampling three plants per plot before application and 7 and 14 DAT. Leaf/stems, pods, and seeds were evaluated separately.

Study 1: At Minot, visual leaf and pod desiccation were similar across adjuvants, which did provide faster desiccation compared to the untreated control. However, stem desiccation was faster with MSO compared to PO and NIS. In actual plant moisture sampling, MSO reduced stem/leaf moisture more than PO or NIS at 7 DAT. However, pod and seed moisture were similar across treatments, including the untreated control at 7 and 14 DAT.

At Scottsbluff, MSO and PO provided greater visual desiccation than NIS at 5 DAT; however, there were no differences between adjuvants or spray volume at 10 DAT. In actual plant moisture sampling, stem/leaf, pod, and seed moistures were similar across all treatments, including the untreated control.

At Fargo, dry bean desiccation generally was as follows: MSO ≥ PO ≥ NIS > untreated. The greatest separation was with stem desiccation at 14 DAT where MSO provided 93% desiccation compared to 83 and 65% for PO and NIS, respectively. Saflufenacil plus MSO applied at 47 L/ha generally provided 5-10% less desiccation than at 94 L/ha.

In summary, MSO tended to provide more visible desiccation than PO and NIS; however, actual plant moisture sampling indicated that the desiccant may have provided faster leaf/stem dry down, but did not reduce pod and seed moisture more than natural desiccation. Saflufenacil plus MSO at 94 L/ha generally provided equal or greater desiccation compared to 47 L/ha.

Study 2: At Minot, while results varied slightly among individual plant parts, overall visual desiccation tended to be as follows: saflufenacil ≥ flumioxazin ≥ carfentrazone ≥ glyphosate ≥ untreated at 4 and 7 DAT. By 10 DAT, desiccation was generally similar among treatments, with the exception of stem desiccation where carfentrazone and glyphosate were slower compared to other treatments. At Scottsbluff, visual desiccation results were generally similar to Minot. The addition of glyphosate to saflufenacil, flumioxazin, and carfentrazone increased visual desiccation 10-20%.

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At Minot, actual stem/leaf moisture results showed a similar trend to the visual evaluations: Stem/leaf desiccation tended to be as follows: saflufenacil ≥ flumioxazin ≥ carfentrazone ≥ glyphosate ≥ untreated. In contrast, pod and seed moistures were similar among treatments including the untreated control.

At Scottsbluff, visual desiccation results were generally similar to Minot. Paraquat provided faster visual desiccation (93%) than all other treatments (53-81%) at 5 DAT. However, by 10 DAT all treatments provided >92% overall desiccation. In the actual plant moisture sampling, there were no differences among treatments in stem/leaf, pod, or seed moistures.

At Fargo, visual desiccation results were generally similar to Minot and Scottsbluff with saflufenacil ≥ flumioxazin > carfentrazone > glyphosate ≥ untreated.

In summary, similar to the adjuvant study, the various desiccants appeared to dry down leaf material faster than natural desiccation, but did not reduce actual pod and seed moisture more than natural desiccation.

INTERACTION BETWEEN SOIL NITROGEN AND IMAZAMOX ON PALMER AMARANTH CONTROL IN SUNFLOWER. Amar S. Godar, Phillip W. Stahlman, and J. Anita Dille, Graduate Research Assistant, Department of Agronomy, Kansas State University, Manhattan, KS 66506, Research Weed Scientist, Kansas State University Agricultural Research Center, Hays, KS 67601, and Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Greenhouse and field experiments were conducted in Kansas in 2008 and 2009 to investigate the interaction between soil N level and imazamox rate on Palmer amaranth control and crop seed yield in imidazolinone-tolerant sunflower. Treatments included factorial arrangements of three soil N levels (28, 56, and 84 kg/ha) and two imazamox rates (26 and 35 g ai/ha) plus no imazamox and hand weeded control treatments. Density of Palmer amaranth in greenhouse experiments was 400 plants/m^2 and density in field experiments was ~100 and 20 plants/m^2 in 2008 and 2009, respectively. In both greenhouse and field experiments at the time of imazamox application, height of Palmer amaranth plants grown in the highest soil fertility treatment was taller than recommended on the imazamox label and taller than plants in the two lower soil fertility treatments. Differences in Palmer amaranth height between soil N levels in the 2009 field experiment were smaller than in all other experiments. Palmer amaranth biomass reduction did not differ between imazamox rates at any of the three soil N levels in the 2009 field experiment, or at the 56 kg/ha soil N level in all other experiments. However, the 35 g/ha rate of imazamox was more effective than the 26 g/ha rate at the lowest and highest fertility levels. These results indicate that the lower-than-labeled rate of imazamox tested (26 g/ha) can be as effective as the recommended use rate (35 g/ha) when soil N level is not limited and size of Palmer amaranth plants does not exceed label recommendation, but the labeled rate is more effective under condition of low soil fertility and on larger, rapidly-growing plants. Sunflower seed yield in 2008 was not determined because of heavy bird predation. In 2009, soil N level did not affect sunflower yield except in hand weeded plots. Averaged over soil N level, sunflower treated with 26 and 35 g/ha rates of imazamox yielded similarly and averaged 75% higher yield compared to the no imazamox treatment. These results indicate that herbicide application is more important than soil N level in preventing seed yield loss from moderate densities of Palmer amaranth infestation in sunflower.

MANAGEMENT OF GLYPHOSATE-RESISTANT GIANT RAGWEED IN SUGARBEET. Jason M. Fisher, Jeff M. Stachler, and John L. Luecke, Graduate Research Assistant, Assistant Professor, and Research Specialist, Department of Plant Sciences, North Dakota State University and University of Minnesota, Fargo, ND 58108-6050.

Glyphosate-resistant giant ragweed was identified in southern Minnesota in 2006. Glyphosate-resistant giant ragweed continues to increase in southern MN, especially near Hutchinson, MN. Controlling glyphosate-resistant giant ragweed with glyphosate only in the newly (2007) introduced glyphosate-resistant sugar beet will be difficult in this area of MN. Small-plot field research was conducted in 2009 at two locations near Hutchinson, MN to determine the response of glyphosate-resistant sugarbeet and giant ragweed to clopyralid and glyphosate at various rates, timings, and number of applications. Factors in the study consisted of herbicide timing (giant ragweed heights of 2.5, 7.6, and 15.2 cm at initial application) and treatments. Treatments at each timing included glyphosate (840 g ae/ha) applied alone and in combination with clopyralid at 8.6, 17.2, and 34.5 g ae/ha) in a single application. In addition, clopyralid was applied twice at 8.6 and 17.2 g ae/ha and 17.2 followed by 34.5 g ae/ha and three times at 17.2 g ae/ha and 8.6 followed by 8.6, followed by 17.2 g ae/ha. Applications were applied to the four middle rows of each plot at a length of 12 m with a carbon dioxide pressurized bicycle sprayer. Fifteen giant ragweed plants were flagged in each plot prior to the initial applications. Visual whole plot and individual plant evaluations were recorded 21 days after each application and at harvest. The sugarbeets were harvested in September 1st.

Glyphosate applied in a single application at the three initial timings controlled giant ragweed less than 25% at harvest. Giant ragweed control was greater than 93% at harvest when clopyralid and glyphosate was applied twice totaling 51.7 g ae/ha or applied three times. Individual plant mortality at harvest was 99% or greater when clopyralid was applied at $\geq$ 17.2 g ae/ha to 2.5 cm giant ragweed and at $\geq$ 34.5 g ae/ha to 7.6 cm giant ragweed. Maximum sugarbeet yields ranged from 31 to 45 metric tons/ha when clopyralid plus glyphosate was applied in multiple applications to 2.5 or 7.6 cm giant ragweed.

This field research confirms the presence of glyphosate-resistant giant ragweed near Hutchinson, MN. Clopyralid must be applied two or more times in combination with glyphosate to 7.6 cm or smaller giant ragweed to maximize sugar beet yield and eliminate nearly all flagged plants.

A COMPUTER-GUIDED FLAME WEEDER FOR WEED CONTROL IN CARROT AND SNAP BEAN. Chad M. Herrmann and Bernard H. Zandstra, Graduate Assistant and Professor, Michigan State University, East Lansing, MI 48824.

A precision-guided flame weeder was developed for shielded weed control in emerged vegetable crops. The machine is equipped with an Eco-Dan® local positioning system which uses camera and computer guidance technology to detect a crop row and position the weeder accurately in relation to the row. Four 1.5 m long stainless steel shields are installed on the toolbar, and 500,000 kJ liquid propane torches are mounted under each shield. Several experiments were conducted in 2008 and 2009 to evaluate postemergence weed control with the flame weeder in snap bean and carrot. Each crop was planted with three single rows per plot with row spacing of 41 cm. There was a 5 cm wide band centered on each crop row that remained untreated, so approximately 90% of the total plot area was treated. Plots were treated when snap beans had one expanded trifoliate leaf and most weeds had 4-6 true leaves. Treatments were applied to carrots when plants had 1-2 fern leaves and weeds had 4-8 leaves.

A factorial arrangement in a RCB design was used to assess combinations of propane pressure and ground speed. In the snap bean evaluations, propane pressures of 0.07, 0.17, 0.24, and 0.31 MPa were applied at ground speeds of 1.6, 3.2, 5.6, and 8.0 km/hr. Plots treated at 1.6 km/hr resulted in snap bean injury, and injury increased from 36-60% proportionally with increasing propane pressure at that speed. All treatments with ground speeds greater than 1.6 km/hr did not result in snap bean injury. Carrots were more susceptible to thermal injury than snap beans, and 30-38% crop injury occurred in treatments of 0.17 MPa or higher and ground speed of 3.2 km/hr. Visual ratings, weed counts, and weed biomass were assessed for redroot pigweed, common lambsquarters, common purslane, and large crabgrass. Propane pressures of 0.17, 0.24, and 0.31 MPA with ground speeds of 1.6 or 3.2 km/hr controlled 83-97% of both redroot pigweed and common lambsquarters. Common purslane and large crabgrass were more difficult to control and often regrew, but 83-85% control of common purslane and 75-83% control of large crabgrass was achieved when treated at 0.31 MPa and 1.6 km/hr. Propane fuel usage was related proportionally to pressure in a linear manner, and the most effective treatments in terms of both efficacy and crop safety consumed propane at approximately 20-30 kg/ha.

TOLERANCE OF POTATO MINI-TUBERS TO PRE AND POST HERBICIDE APPLICATIONS.
Calvin F. Glaspie*, Wesley J. Everman, Christopher M. Long and Andrew J. Chomas, Graduate Student, Assistant Professor, Extension Specialist, Research Assistant, Michigan State University, Department of Crop and Soil Sciences, East Lansing, MI 48824.

Demand for disease free potato seed in Michigan is high due to an increased economic return upon planting disease and virus free seed potatoes. Using aseptically grown plants produced from tissue culture, potato mini-tubers can be planted as a clean seed source. However, many generally accepted cultural practices for managing mini-tubers are adopted from cut seed piece, including weed management programs. Field trails were conducted at the Montcalm Research Farm near Entrican, MI in 2008 and 2009 to evaluate the effect of labeled herbicide programs on three cultivars of potato mini-tubers. Potato cultivars Atlantic and two Frito Lay (FL) varieties were planted in 34 in rows, 2.5 in deep at 8 in spacing and hilled at planting. Fifteen herbicide treatments were arranged in a split plot design with four replications. Treatments included PRE applications of dimethenamid at 0.66 lb ai/A, imazosulfuron at 0.4 lb ai/A, KIH-485 at 1.26 lb ai/A, linuron at 0.5 lb ai/A, *s*-metolachlor at 1.27 lb ai/A, metribuzin at 0.5 lb ai/A, pendimethalin at 0.72 lb ai/A, rimsulfuron at 0.023 lb ai/A, *s*-metolachlor plus linuron, *s*-metolachlor plus linuron plus metribuzin at 0.09 lb ai/A, *s*-metolachlor plus metribuzin at 0.09 lb ai/A plus pendimethalin at 0.24 lb ai/A, and *s*-metolachlor plus metribuzin at 0.09 lb ai/A plus pendimethalin at 0.24 lb ai/A plus glyphosate at 0.77 lb ai/A plus ammonium sulfate at 3.5 lb/A; PRE followed by (fb) POST treatments of *s*-metolachlor plus linuron fb rimsulfuron at 0.0016 lb ai/A plus non-ionic surfactant (NIS) at 0.05 gal/A, *s*-metolachlor plus linuron fb metribuzin at 0.28 lb ai/A plus rimsulfuron at 0.0016 lb ai/A plus NIS at 0.05 gal/A and a non-treated control with all plots maintained weed free by hand. The study was managed according to local production practices. Visual injury was rated throughout the season on a 0-100% scale and yield data was collected at end of season for tuber yield and quality. Injury was observed in both years and was similar across varieties tested. Treatments of *s*-metolachlor plus linuron in both years caused leaf chlorosis and malformation while rimsulfuron and dimethenamid were only observed to cause injury in 2009. Imazosulfuron and treatments containing POST applications of rimsulfuron were found to reduce yields in 2008 while *s*-metolachlor alone and *s*-metolachlor plus metribuzin plus pendimethalin with or without glyphosate reduced yields in 2009. This study indicates several currently labeled herbicides may cause visual injury during the season and yield reductions on potato mini-tubers.
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FIELD CORN TOLERANCE TO BROADCAST FLAMING. Santiago M. Ulloa*, Avishek Datta, Stevan Z. Knezevic, Chris Bruening, George Gogos, Goran Malidza, and Robert Leskovsek. Graduate Student, Post Doctoral Research Associate, and Associate Professor, Haskell Agricultural Laboratory, University of Nebraska, Concord, NE 68728, USA; Graduate Student, and Professor, Mechanical Engineering, University of Nebraska, Lincoln, NE 68588, USA; Research Associate, Institute of Field and Vegetable Crops, M. Gorkog 30, Novi Sad, 21000, Serbia; Graduate Student, Agricultural institute of Slovenia, Hacquetova 17, 1000, Ljubljana, Slovenia.

Propane flaming could be an additional tool for weed control in organic field corn production. However, field corn tolerance to broadcast flaming must be determined first to optimize the use of propane. Two field experiments were conducted at the Haskell Agricultural Laboratory, Concord, NE in 2008 to determine field corn response to five propane rates applied at three growth stages of V5 (5 leaves), V7, and V9. The propane rates included were 0, 12, 24, 42, and 75 kg/ha (0, 2.5, 5, 8.5, and 15 gal/acre). Flaming treatments were applied utilizing an ATV mounted flamer moving at a constant speed of 6.5 km/h (4 m/h). The response of field corn to propane flaming was evaluated in terms of visual injury ratings (1, 7, 14, and 28 DAT), effects on yield components (plants/m^2, cob/plant, kernels/cob, and 100-seed weight), and grain yield. The response of different growth stages of field corn to propane rates was described by log-logistic models. In general, V5 was the most tolerant stage for broadcast flaming. Although, all growth stages exhibited similar injury levels at 14 and 28 DAT, the V5 stage had the least yield loss. In contrast, V7 and V9 stages were more susceptible to flaming resulting in higher loss of yields and yield components. The maximum yield reductions for the highest propane rate of 75 kg/ha were 2% for V5, 8% for V9, and 9% for V7 stage. Based on these results, flaming has a great potential to be used effectively in organic corn production. santiago@huskers.unl.edu

CONTROL OF GLYPHOSATE-RESISTANT CORN IN A CORN REPLANT SITUATION. Ryan M. Terry, Paul T. Marquardt, William G. Johnson and Mark Loux, Graduate Research Assistant, Research Associate and Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907, Professor, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210.

Control of glyphosate-resistant (GR) corn in a replant situation with herbicides labeled for use in corn is difficult. In addition, little is known about the effect of poor initial stand on replanted corn yields. The study objectives were to evaluate the efficacy of various herbicides on an initial corn stand in a corn replant situation and to determine the impact of poor initial stand control on corn grain yield. In 2009, studies were conducted near Lafayette, IN and South Charleston, OH. The initial corn stand was planted May 23, 2009 at 79,000 seeds ha^{-1}. Three hybrid blends were planted consisting of 100% GR corn, 50/50 GR/non-GR blend and 25/75 GR/non-GR. Glyphosate was applied to create different corn populations at replant. A GR and glufosinate-resistant hybrid was replanted at 79,000 seeds ha^{-1} on June 15, 2009. Clethodim applied six days before replanting, paraquat plus metribuzin applied two days after replanting, glufosinate applied two days after replanting, and glufosinate applied 2 days after replanting along with a sequential treatment three weeks after replanting provided 99 to 100% control of the initial corn stands.

GRASS EFFICACY WITH THIENCARBAZONE METHYL AND COMBINATIONS WITH TEMBOTRIONE AS INFLUENCED BY APPLICATION TIMING. Daniel K. Tiedemann, Bryan G. Young, Ronald F. Krausz, and Joseph L. Matthews, Graduate Research Assistant, Professor, and Researchers, Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901.

Thiencarbazone-methyl (TCM) is an ALS-inhibiting herbicide for foliar and residual control of grasses and broadleaf weeds in corn. Currently, TCM is sold commercially exclusively as a premix with other herbicide active ingredients and is not available alone. However, a basic understanding of the efficacy that TCM provides in these herbicide combinations would be beneficial in efforts to optimize foliar adjuvant systems or as a foundation for building best management practices for deterring the development of herbicide-resistant weeds. Therefore, field experiments were conducted in field corn in 2008 and 2009 to: 1) assess the grass efficacy from TCM and tembotrione independently and as a formulated premix of TCM:tembotrione and 2) compare TCM with competitive standards for postemergence grass control including topramezone, nicosulfuron, and glyphosate.

The field experiment was a factorial of herbicide treatment (6) and application timing (3) arranged in randomized complete block with three replications. The herbicide treatments were TCM (15 g ai/ha), tembotrione (75 g ai/ha), the premix of TCM:tembotrione (15:75 g/ha), topramezone (17 g ai/ha), nicosulfuron (35 g ai/ha), and glyphosate (860 g ae/ha) applied at an early postemergence (EPOST), mid-postemergence (MPOST), and a late postemergence (LPOST) timing. The height of grass weeds ranged from 0 to 7.5, 8 to 15, and 16 to 22.5 cm for the EPOST, MPOST, and LPOST application timings, respectively.

All treatments containing TCM resulted in an initial corn response of 5 to 13% in the form of shortened internodes at 7 days after treatment (DAT). Corn injury dissipated and was no longer visible by 14 DAT. Control of fall panicum and giant foxtail at 28 DAT ranged from 88 to 98% for the EPOST and MPOST applications of TCM, TCM:tembotrione, nicosulfuron, topramezone, and glyphosate with no difference in control between the timings. Delaying the application of these herbicides to the LPOST timing reduced control of fall panicum and giant foxtail by up to 43 and 32%, respectively, with the least reduction in control observed for glyphosate. Fall panicum control was 30% or less for any application timing of tembotrione alone. Furthermore, the addition of tembotrione to TCM did not enhance control of fall panicum for in any instance. Control of giant foxtail with tembotrione alone was equivalent to TCM applied alone at the EPOST and MPOST timing. However, giant foxtail control with tembotrione applied alone at the LPOST timing was greater than either TCM applied alone or the premix of TCM:tembotrione.

UNIVERSITY RESEARCH IN OPTIMUM GAT CORN. David Carruth, Richard Zollinger, Chris Boerboom, Michael Moechnig, and Tom Hoverstad, Graduate Research Assistant, Professor, Department of Plant Science, North Dakota State University, Fargo, ND 58108-6050, Professor, Department of Agronomy, University of Wisconsin, Madison, WI 53706-1597, Assistant Professor, Department of Plant Science, South Dakota State University, Brookings, SD 57007, Scientist, Southern Research & Outreach Center, University of Minnesota, Waseca, MN 56093-2837.

The Optimum GAT trait provides metabolism of glyphosate as well as tolerance to ALS herbicides. The development of this technology offers growers a wide range of herbicides that can be applied both preemergence (PRE) and postemergence (POST). The herbicide systems will provide contact plus residual activity and two different modes of action that may help reduce resistant and tolerant weeds. DuPont has developed one and two pass weed control programs based on geographic location to be used in Optimum GAT corn. Treatments in these programs include combinations of glyphosate, ALS herbicides, and other corn labeled products. In 2009, treatments were applied on Optimum GAT corn at Prosper, ND, Brookings, SD, Waseca, MN, and Arlington, WI. Treatments for the two pass program included a PRE application followed by a post application when weeds reached 10-15 cm. Treatments for the one pass program included an early POST application at the V2 stage or a mid-post application when weeds reached 10-15 cm. Weed control was evaluated at different application timings for the weed species present at each location. Weed control ratings from PRE applications were highly variable from one location to another. Post treatments applied after a PRE provided at least 90% control of all weed species approximately one month after application at all four locations. The early POST application gave at least 83% control of all weed species 28 days after application at three of the four locations. Treatments applied at the mid-post timing also provided 73-99% control of weed species at all locations. This data shows that these one and two pass weed control programs can provide excellent weed control in northern Midwest states.

QUIZALOFOP EFFICACY ON ACETYL COENZYME-A CARBOXYLASE RESISTANT GRAIN SORGHUM AS AFFECTED BY APPLICATION RATE AND TIMING. M. Joy M. Abit, Kassim Al-Khatib, Phillip W. Stahlman, and Patrick W. Geier, Graduate Research Assistant, Professor, Professor, and Assistant Scientist, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Postemergence herbicide grass control is very limited in conventional grain sorghum production due the plant's high susceptibility to these herbicides. The development of acetyl coenzyme-A carboxylase resistant grain sorghum has broaden postemergence grass control in grain sorghum. Field experiments were conducted at Hays and Manhattan, KS to determine the efficacy of quizalofop on acetyl coenzyme-A carboxylase resistant grain sorghum at different application rate and timing. Quizalofop was applied at 62, 124, 186, and 248 g ai/ha at heights of 8 to 10, 15 to 25, and 30 to 38 cm, which correspond to early postemergence (EPOST), mid-postemergence (MPOST), and late postemergence (LPOST), respectively. Grain sorghum injury in the form of epinasty and stunting ranged from 0 to 46% and 3 to 68%, respectively, 1 wk after treatment (WAT); by 4 WAT plants generally recovered from injury. Quizalofop applied at EPOST injured grain sorghum more than when applied at MPOST and LPOST timings. The EPOST application injured grain sorghum 9 to 68%, whereas injury from MPOST and LPOST was 2 to 48% and 0 to 16%, respectively, depending on rate. Crop injury from quizalofop was more pronounced at 248, 186, and 124 g/ha than at the use rate of 62 g/ha. Sorghum grain yield was not affected by quizalofop injury as there were not significant differences in grain yield between herbicide-treated and -untreated plots regardless of rate and timing.

BENCHMARK STUDY: SEEDBANK EMERGENCE PATTERNS IN BEST MANAGEMENT PRACTICES FIELDS VERSUS GROWER PRACTICES. Robert G. Wilson, Gustavo M. Sbatella, Stephen C. Weller, Bryan G. Young, David L. Jordan, Micheal D.K. Owen, Philip Dixon, and David R. Shaw, Professor and Post-doc, University of Nebraska, Scottsbluff, NE 69361, Professor, Purdue University, West Lafayette, IN 47907, Professor, Southern Illinois University, Carbondale, IL 62901, Professor, North Carolina State University, Raleigh, NC 27695, Professor and Professor, Iowa State University, Ames, IA 50011, Professor, Mississippi State University, Mississippi State, MS 39762.

A multi-state, four-year field scale study was initiated in 2006 to assess the impact of weed management tactics on weed populations in glyphosate-resistant (GR) crops. A total of 155 commercial fields in Illinois, Indiana, Iowa, Mississippi, Nebraska and North Carolina were included in the study and seedbank, weed populations and yields were enumerated during the growing season. Fields selected for the project in 2006 had been in a glyphosate-resistant cropping system for the previous 3 yr. Each field was divided into two sections with half managed for weed control as typical for the grower and the other half managed following recommendations by a university weed specialist within the state. Forty sample locations were established throughout each field with GPS coordinates within the two sides of the study site. Cropping systems examined in the study included; continuous GR crop (corn, soybean, and cotton), a rotation of two GR crops and a rotation of a GR crop and a non-GR crop. The seedbank was measured each spring by taking a 6.4 cm diameter by 15 cm deep soil core in 20 locations in each half of the field. Soil samples were kept separate and placed in a greenhouse and exposed to three cycles of wetting, drying and freezing conditions over a 104-day period and weed seedling emergence was utilized to estimate the weed seedbank during each cycle. Measurement of the seedbank in the spring of 2006 indicated that weed seed density was similar in the grower and university sections of the field for each of the seven cropping systems. However the seedbank in fields that had previously been in continuous glyphosate-resistant soybean (GRS) had a greater seed density than fields in a cropping system of continuous glyphosate-resistant corn (GRC). Interestingly by rotating GRS with another glyphosate-resistant crop reduced the number of weed seed in the seedbank and the number of weed seedlings emerging before crop planting compared to continuous GRS. In the spring of 2007 the number of seed in the seedbank in the grower and university managed sections of the field were again similar for all cropping systems except GRS rotated with a non-glyphosate-resistant crop. These studies have continued and results will allow us to further delineate the influence of cropping systems and degree of weed management on species shifts and resistance management.

CALLISTO XTRA HERBICIDE FOR POSTEMERGENCE BROADLEAF WEED CONTROL IN CORN. Ryan D. Lins*, Gordon D. Vail, and Carroll M. Moseley, Syngenta Crop Protection, Greensboro, NC.

Callisto® Xtra is a new, post-emergence corn herbicide that combines the proven performance of mesotrione (Callisto®) and atrazine (AAtrex®) herbicides in a convenient premix. Callisto Xtra will be recommended for use as a tank-mix partner in glyphosate tolerant corn. Trials were conducted in 2009 to confirm the intended efficacy, safety, handling characteristics, and rate flexibility.

ISOXAFLUTOLE + CYPROSULFAMIDE, THIENCARBAZONE + ISOXAFLUTOLE + CYROSULFAMIDE: PERFORMANCE IN UNIVERSITY CORN TRIALS. Kevin K. Watteyne*, Tate Castillo, John R. Hinz, Brent Philbrook and James R. Bloomberg, Bayer CropScience, Research Triangle Park, NC 27709.

Balance WDG (Isoxaflutole) was introduced into the corn market during 1999, with widespread acceptance to a new-mode of action in grass and broadleaf control in the Midwest corn market from pre-emergence applications. Balance Pro, a liquid formulation of Isoxaflutole was later introduced with the same consistent results that had been experienced with Balance WDG. In late 2008, Balance Flexx (Isoxaflutole + Cyprosulfamide) and Corvus (Thiencarbazone + Isoxaflutole + Cyprosulfamide) received EPA registration and were successfully launched into the corn market in 2009.

Balance Flexx and Corvus both contain Cyprosulfamide, an exclusive Bayer herbicide safener technology that makes Crop Safety Innovation (CSI) possible. CSI has both soil and foliar uptake allowing both products to have excellent crop safety from pre-emergence to early post emergence (V2) applications in corn. Both products control approximately 90 broadleaf and grass weed species including ALS-, triazine-, and glyphosate- resistant weeds. Balance Flexx and Corvus & Balance Flexx still have the unique power of re-activation after subsequent moisture with excellent burndown capabilities. Both Balance Flexx and Corvus use low use rates-apply ounces vs. pints and quarts with other pre-emergence herbicides.

Corvus is a new one-pass corn herbicide containing two modes of action. The first, known as a bleacher (isoxaflutole), inhibits the HPPD enzyme in the plants. HPPD is key to the production of protective pigments in the plants. The second, thiencarbazone, inhibits the acetolactate synthase enzyme, thus preventing the production of three essential branch-chain amino acids (thiencarbazone).

Studies were conducted in 2008 and 2009 by Bayer CropScience and all major Midwestern universities in major corn growing states. These trials confirmed the excellent crop safety of the products and the good to excellent activity on hard-to-control grass and broadleaf weeds and on herbicide-resistant weeds such as Palmer amaranth, marestail and tall waterhemp.

CONTROL OF GLYPHOSATE-RESISTANT AND SUSCEPTIBLE WEEDS WITH 2,4-D ALONE OR IN TANK MIXES WITH GLYPHOSATE. Eric F. Scherder, Marvin E. Schultz, Mark A. Peterson, Jeffrey M. Ellis, Scott C. Ditmarsen, Kevin W. Bradley, Reid J. Smeda and William G. Johnson, Dow AgroSciences, Indianapolis, IN 479076, Associate Professor and Associate Professor, Division of Plant Sciences, University of Missouri, Columbia, MO 65211, Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

2,4-D has provided broad-spectrum, broadleaf weed control in a wide range of crops for many years, but utility in some crops has been limited due to unacceptable crop tolerance. Dow AgroSciences has recently announced the development of a new family of traits that will enable the use of 2,4-D at rates and application timings that were previously impractical. Field studies have been conducted to evaluate the performance of 2,4-D amine alone at rates ranging from 560 to 1120 g ae/ha alone or in combination with glyphosate. Results indicate that 2,4-D provides greater than 90% control of several key broadleaf weed species that are difficult to control with glyphosate alone. In addition, combinations of 2,4-D with glyphosate generally provide more consistent control of many glyphosate-susceptible weed species.

EFFECT OF WEED SIZE ON CONTROL OF WEEDS WITH 2,4-D + GLYPHOSATE TANK MIXES IN CORN. David E. Hillger*, Marvin E. Schultz, Dave C. Ruen, Bruce E. Maddy, A. Stanley Culpepper, Mark M. Loux, and Bryan G. Young, Field Scientists, Dow AgroSciences, Indianapolis, IN 46268, Professor, University of Georgia, Tifton, GA 31794, Professor, The Ohio State University, Columbus, OH 43210 and Professor, Southern Illinois University, Carbondale, IL 62901.

Weed size can significantly affect the level of control achieved with glyphosate. This effect can be accentuated in weed biotypes that have developed some level of resistance to glyphosate. The addition of 2,4-D to glyphosate may provide more consistent control of larger broadleaf weeds than that achieved with glyphosate alone. Dow AgroSciences has recently announced the development of a new family of traits that will enable the use of 2,4-D at rates and application timings that were previously impractical. Field studies have been conducted to evaluate the performance of 2,4-D amine at rates ranging from 560 to 1120 g ae/ha in combination with glyphosate on 5-10, 15-20, and 25-30 cm weeds. Results indicate that 2,4-D improved control of several key broadleaf weed species at larger growth stages as compared to glyphosate alone.

CAPRENO™ (THIENCARBAZONE-METHYL + TEMBOTRIONE + ISOXADIFEN-ETHYL): A NEW HERBICIDE FOR GRASS AND BROADLEAF WEED CONTROL IN CORN. George S. Simkins*, David Lamore, Jerry Hora, Brent Philbrook and James R. Bloomberg, Bayer CropScience, Research Triangle Park, NC. (121)

Capreno is a new postemergence corn herbicide premix from Bayer CropScience that consists of thiencarbazone-methyl + tembotrione + isoxadifen-ethyl. It may be applied in emerged corn for burndown of emerged weeds, as a 'one pass' postemergence treatment, or as the postemergence component of a 'traditional' two-pass herbicide program. Capreno offers growers two differing modes of action for control of grass and broadleaf weeds, including weeds resistant to glyphosate and other chemical classes. Capreno herbicide active ingredients are formulated as a 33.9 % suspension concentrate (SC) formulation. The suggested use rate of Capreno is 90.7 g herbicide ai ha-1 and the product should always be tank mixed with an external surfactant and a nitrogen fertilizer adjuvant to optimize weed control. Application timing is optimized in corn from burndown to V5 which prevents early weed competition and exploits the residual activity of Capreno.

Research trials conducted by Bayer CropScience and University researchers in 2008 and 2009 have demonstrated the following results: Early postemegence applications (V1 to V5) of Capreno combined with crop oil concentrate and a nitrogen fertilizer source provided control of most annual grass and broadleaf weeds. The addition of atrazine to this combination enhanced the weed control (~ 5%) provided by this treatment. Early postemergence Capreno applications provided superior weed control as compared to mid-postemergence applications. Capreno provided residual control of both grass and broadleaf weed up to crop canopy closure.

EVALUATION OF HERBICIDES IN OPTIMUM GAT CORN. Dean M. Grossnickle*, Micheal D.K. Owen, James F. Lux, and Damian D. Franzenburg. Iowa State University, Ames, IA.

In 2009, Iowa State University conducted research evaluating weed control and herbicide injury in corn with traits that convey tolerance to glyphosate and acetolactate synthase inhibitor herbicides. The weeds that were evaluated were giant foxtail, velvetleaf, common lambsquarters, common waterhemp, and ivyleaf morningglory and the trial was established on the Curtiss Farm research facility in Ames, IA. Corn was planted on May 31 in ground that was prepared with field cultivation. Three herbicide application timings with combinations of herbicides were evaluated at 0, 7, 14, 21, and 28 days after application (DAA). One pass preemergence (PRE) applications were applied on May 31. Two pass PRE followed by (fb) postemergence (POST) applications were applied on May 31 PRE and June 29 POST when weeds were 5-21 cm tall. The third timing was a one pass POST application that was applied on June 27 to 10-21 cm tall weeds. All treatments were applied in a carrier volume of 187 l ha^{-1} and POST applications were applied with ammonium sulfate at 2.24 kg ha^{-1}. Herbicides that were evaluated were combinations and rates of rimsulfuron (2.87 and 3.73 g ai ha^{-1}), chlorimuron-ethyl (.95 and 3.73 g ai ha^{-1}), mesotrione (14.35 and 24.68 g ai ha^{-1}), atrazine (183.70 and 229.63 g ai ha^{-1}), s-metolachlor and atrazine (378.89 and 631.48 g ai ha^{-1}), glyphosate 142.37 g ae ha^{-1}, tribenuron (1.43 and 2.16 g ai ha^{-1}), acetochlor 146.96 g ai ha^{-1}, thifensulfuron-methyl 1.43 g ai ha^{-1}, and dicamba 22.96 g ai ha^{-1}.

None of the herbicide treatments exhibited injury symptoms when evaluated 7 DAA. In the one pass POST programs 14 DAA, all herbicide treatments provided equal control of giant foxtail, velvetleaf, and ivyleaf morningglory. One treatment that included atrazine at 183.70 g ai ha^{-1} had significantly less (6%) control of common lambsquarters and one treatment with thifensulfuron-methyl was also significantly reduced by 3% for the control of common waterhemp. The PRE fb POST treatments provided equal control for all weeds evaluated. When comparing the one pass PRE to the one pass POST and PRE fb POST treatments, s-metolachlor and atrazine control declined significantly 10-50% for giant foxtail, velvetleaf, and ivyleaf morningglory than other POST and PRE fb POST treatments. The PRE rimsulfuron at 3.73 g ai ha^{-1} provided 13-21% less control of giant foxtail than all other POST and PRE fb POST treatments but provided equal control for all other weeds. At 28 DAA, all treatments demonstrated only a 0-3% decline in control when compared to the 14 DAA evaluations.

OPTIMUM® GAT® CORN – HERBICIDE PROGRAMS FOR THE NORTH CENTRAL STATES. Kevin L. Hahn*, Keith Johnson, Larry H. Hageman and David W. Saunders, Product Development Representative, DuPont Crop Protection, Johnston, IA 50131.

Weed control programs designed for use on corn containing the Optimum® GAT® trait are under development. Integrated herbicide programs making use of preemergence, postemergence, and 2-pass weed control strategies were evaluated by DuPont, university, and contract investigators in 2009. Data will be presented supporting the use of Optimum® GAT® trait crops as new tools for managing weed control problems including herbicide resistance weeds across the United States. Seed products with the Optimum® GAT® trait will be available for sale pending regulatory approvals and field testing. New DuPont herbicides for the Optimum® GAT trait® are not currently registered for sale or use in the United States.

PYRASULFOTOLE&BROMOXYNIL, POTENTIALLY A NEW HERBICIDE FOR WEED CONTROL IN GRAIN SORGHUM. Curtis R. Thompson, Nathan G. Lally, Brian L.S. Olson, Randal S. Currie, Alan J. Schlegel, Pat W. Geier, and Phillip W. Stahlman, Professor and Graduate Research Assistant, Agronomy Department, Kansas State University, Manhattan, KS 66506, Assistant Professor, Northwest Research Extension Center, Kansas State University, Colby, KS 67701, Associate Professor and Professor, Southwest Research Extension Center, Garden City and Tribune, KS, 67846 and 67879, Research Scientist and Professor, Kansas State University Agric. Research Station, Hays, KS 67601.

Weed control in grain sorghum continues to be a challenge because of the limited number of herbicide products available to growers and the increasing concerns with herbicide resistant weeds. Field experiments were conducted near Tribune, Manhattan, Garden City, Colby, and Hays, KS in 2009, to evaluate a prepackaged mixture of pyrasulfotole&bromoxynil (1:8 ratio) plus atrazine alone, and in combination with 2,4-D amine, 2,4-D ester, or dicamba for grain sorghum tolerance and weed control. Grain sorghum hybrids were planted and dimethenamid-P at 840 g/ha was applied to the soil surface. Pyrasulfotole&bromoxynil at 244 g/ha was tank mixed with atrazine at 560 g/ha only or in combination with 2,4-D ester at 140 g/ha, 2,4-D amine at 210 g/ha, or dicamba at 140 g/ha. Herbicide treatments were applied postemergence to 2 to 6-leaf (early) and 7 to 9-leaf (late) sorghum. Crop response and weed control were evaluated visually. Sorghum injury ratings at all locations ranged from 0 to 24% injury 5 to 9 days after application. The addition of 2,4-D amine or dicamba to pyrasulfotole&bromoxynil+atrazine reduced or tended to reduce sorghum injury 4 to 5% compare to injury from pyrasulfotole&bromoxynil+atrazine alone. In one instance, the addition of 2,4-D ester reduced crop injury slightly while in another instance, 2,4-D ester increased crop injury compared to pyrasulfotole&bromoxynil+atrazine. Crop injury ratings 3 to 4 weeks after treatment application were very near zero at all locations. At the three locations harvested, no herbicide treatment reduced sorghum yield compared to the dimethenamid-P treated check. All treatments containing pyrasulfotole&bromoxynil+atrazine controlled redroot pigweed, Palmer amaranth, common lambsquarters, velvetleaf, common sunflower, and ivyleaf morningglory regardless of the stage of application. Treatments containing pyrasulfotole&bromoxynil+atrazine applied at the early stage at Colby and early and late stages at Garden City controlled kochia 93% or more. Kochia control from treatments containing pyrasulfotole&bromoxynil+atrazine applied at the later stage at Colby were inconsistent ranging from 57 to 93% control. All treatments controlled puncturevine regardless of stage of application at Garden City and when applied early at Hays. Control of puncturevine was inconsistent among herbicide treatments at Tribune and Colby, ranging from 74 to 96% at Tribune, and 50 to 90% control at Colby. Early applications provided best control of puncturevine at Colby while late applications provided the best control in Tribune. These results indicate that grain sorghum has adequate tolerance to postemergence applied pyrasulfotole&bromoxynil+atrazine regardless of the tank mix partner evaluated in these experiments. Excellent control of several problems weeds is an indication of the enhanced value the herbicide could bring to a weed control program in grain sorghum. However at this time, pyrasulfotole&bromoxynil is not registered for use in grain sorghum.

SULFONYLUREA AND QUIZALOFOP TOLERANCE TRAITS IN SORGHUM – NEW WEED MANAGEMENT TOOLS FOR SORGHUM PRODUCTION. Robert N. Rupp, Douglas J. Meadows, Dave W. Saunders and Wayne J. Schumacher, DuPont Crop Protection, Johnston, IA 50131-2430

Kansas State University Researchers have developed non-GMO sulfonylurea and quizalofop herbicide tolerance traits in sorghum. DuPont Crop Protection has acquired exclusive commercial rights to both tolerance traits and to the use of chemistries enabled by those traits. DuPont Crop Protection will license these herbicide tolerance traits to interested sorghum seed companies. Herbicide active ingredients including nicosulfuron, rimsulfuron and metsulfuron methyl are being evaluated for the sulfonylurea tolerant sorghum and Assure® II for the quizalofop tolerant sorghum. New herbicide offerings enabled by the traits will allow sorghum producers to use new postemergence solutions for grass and broadleaf control in sorghum that have previously not been available. The sulfonylurea trait enables the use of herbicides that control grass and broadleaf weeds with both contact and residual activity. The quizalofop trait enables the use of Assure® II for postemergence control of grass species. A parallel launch of sorghum seed products with complimentary DuPont Crop Protection herbicides is planned, pending herbicide trait development and EPA registration of herbicides.

TOLERANCE OF THREE MILLET TYPES TO SAFLUFENACIL. Phillip W. Stahlman*, Patrick W. Geier, and Leo D. Charvat, Professor and Assistant Scientist, Kansas State University, Hays 67601, and Biology Area Development Manager II, BASF Corporation, Lincoln, NE 68523.

Few herbicides are registered for use in grain and forage-type millets. A field experiment in Kansas in 2006 indicated postemergence-applied BAS 800H (now saflufenacil) caused severe foliar necrosis in white-seeded proso millet and hybrid pearl millet and severely reduced the stand of foxtail millet. However, both the proso millet and pearl millet recovered and grew normally suggesting saflufenacil might have potential for use in millets if applied to soil either preplant or preemergence. Field trials were conducted at Beaver Crossing, NE and Hays, KS in 2009 to evaluate the tolerance of ‘Sunrise’ white-seeded proso millet, ‘Elite II’ hybrid pearl millet, and ‘German Strain R’ foxtail millet to preemergence applications of saflufenacil at 36, 50, and 100 g/ha. Both sites were silt loam soils. Within seven days after application, 28 mm of rainfall was received at the Beaver Crossing site and 68 mm of sprinkler irrigation and rainfall were received at the Hays site. Crop response generally was greater at Beaver Crossing than at Hays suggesting the greater amount of water received at Hays may have diluted the amount of herbicide in and above the seeding zone. Millet types at both sites exhibited differing tolerance to soil-applied saflufenacil and crop response generally increased with increasing saflufenacil rate. Foxtail millet at both sites was much less tolerant to saflufenacil than either proso or pearl millet, and pearl millet exhibited greater tolerance than proso millet, especially at the Beaver Crossing site. Saflufenacil at 36 g/ha reduced foxtail millet stand by 40 to 70% and by more than 90% at the 100 g/ha use rate. In comparison, at Beaver Crossing stand reductions of proso millet and pearl millet were 24 and 0%, respectively, at the 36 g/ha use rate and 33 and 5%, respectively, at the 50 g/ha use rate. At the Hays site, stands of proso and pearl millet were reduced by 6 and 22%, respectively, at the 50 g/ha use rate. Differences in proso millet forage yields at Beaver Crossing and grain yields at Hays between 36 g/ha saflufenacil and untreated control treatments were not significant, but yields at both sites were reduced by saflufenacil at 50 and 100 g/ha. However, the forage yields of pearl millet were not reduced at any of the three rates at either site. These results confirm that saflufenacil has potential for use in proso millet and pearl millet but additional studies are needed to refine use rates and optimum times of application.

AMINOCYCLOPYRACHLOR DEVELOPMENT AND REGISTRATION UPDATE.
Jon S. Claus, Mark J. Holliday, Ronnie G. Turner, Jeff H. Meredith, C. Stephen Williams, Global Development Manager, Global Project Manager, DuPont Crop Protection, Wilmington, DE 19880, US Product Development Manager Non Crop, US Development Manager Pasture and US Project Manager, DuPont Land Management, Memphis, TN 38125,

Aminocyclopyrachlor, an exciting new class of auxin herbicide from Dupont, is under development for non-crop uses such as bareground, brush, right-of-way and turf as well as for range, pasture and invasive weed control. Aminocyclopyrachlor has demonstrated activity on a number of important species such as leafy spurge, mesquite, huisache, field bindweed and brush such as box elder. It also controls a number of glyphosate and ALS resistant weeds such as marestail, Russian thistle, kochia, and prickly lettuce. Aminocyclopyrachlor has exhibited a number of positive stewardship attributes with very low impact to mammals and the environment.

AMINOCYCLOPYRACHLOR BLEND PRODUCTS FOR VEGETATION MANAGEMENT ON RAILROAD AND UTILITY SITES. Ronnie G. Turner, Jerry R. Pitts, Donald D. Ganske, Product Development Manager, Field Development Rep and Field Development Rep, DuPont Land Management, Memphis, TN 38125 and Edison Hidalgo, Jon S. Claus, Research Scientist and Global Development Manager, DuPont Stine-Haskell Research Center, Newark, DE 19711.

Vegetation management is essential for the safe and efficient operation of railroad switch yards, rail lines and electrical substation sites. In these types of bareground weed control situations, aminocyclopyrachlor and aminocylcopyrachlor plus DuPont sulfonylurea (SU) herbicides (developmental blend products) were evaluated in a number of sites across the United States in 2007, 2008 and 2009. Both preemergent and postemergent applications were made to small plot replicated trials using a CO_2 back-pack sprayer. All sites were evaluated at a range of 30 to 360 days after treatment. In these trials, aminocyclopyrachlor at 2 to 4.5 ounces active per acre tank mixed with DuPont SU herbicides provided excellent control of many broadleaf weeds and grasses, such as, Russian thistle, kochia, pigweeds, marestail, Canada thistle, including weeds resistant to ALS inhibitors, triazines and glyphosate. Foliar applications of aminocyclopyrachlor or the aminocyclopyrachlor blend products plus a methylated seed oil adjuvant applied to encroaching brush or vine species at several of these sites provided control of trumpetcreeper, Virginia-creeper, ash, locust, multiflora rose, poison-ivy and common buckthorn. The results observed in these trials will help support registration and labeling efforts for aminocyclopyrachlor blended products in the railroad and electric utility weed management markets.

INVASIVE WEED MANAGEMENT WITH AMINOPYRALID. Byron B. Sleugh*, Mary B. Halstvedt, Daniel C. Cummings, Pat L. Burch, William N. Kline, Vernon B. Langston, David Hillger, Vanelle F. Peterson, Dow AgroSciences LLC, 9330 Zionsville Rd., Indianapolis, IN 46268.

With the introduction of aminopyralid, an innovative, non-restricted use active ingredient from Dow AgroSciences, successful strategies for managing many noxious and invasive species in some of the most ecologically sensitive sites, including pastures and rangeland, can be developed. Aminopyralid is a pyridine carboxylic acid herbicide developed for selective broadleaf weed control in sites such as rangeland, pastures, rights-of-way, non-cropland, and natural areas and was registered under the Environmental Protection Agency's Reduced Risk Pesticide Initiative. Aminopyralid (Milestone VM® Specialty herbicide) has broad range activity on a number of key invasive species, such as Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*), spotted knapweed (*Centaurea maculosa*), common and giant ragweed (*Ambrosia spp.)*, teasel (*Dipsacus spp.)* and many others, and that spectrum is broadened even further when combined with certain other active ingredients. A new product with aminopyralid and metsulfuron (Chaparral™/Opensight™ herbicide) has been developed for use on non-cropland sites including industrial sites, rights of ways, non-irrigation ditch banks, natural areas and grazed areas around those sites. This new combination will control additional noxious and invasive weeds such as wild parsnip, wild carrot, poison hemlock, sericea lespedeza, and multiflora rose. The data show that aminopyralid or aminopyralid + metsulfuron could be used in a long term integrated approach to managing noxious and invasive weeds in various habitats.

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CONTROL OF GIANT HOGWEED (*HERACLEUM MANTEGAZZIANUM*) WITH AMINOPYRALID AND TRICLOPYR. David E. Hillger* and Melissa A. Bravo, Field Scientist, Dow AgroSciences, Indianapolis, IN 46268, Botanist, Pennsylvania Department of Agriculture, Harrisburg, PA 17110.

Aminopyralid, with the trade name of Milestone™ VM, is a pyridine herbicide from Dow AgroSciences LLC (DAS) designed and developed specifically for natural land management areas, range and pastures, rights-of-way, industrial vegetation management sites and natural areas such as wildlife habitats, recreation and wildlife management areas. Aminopyralid was registered under the US EPA's Reduced Risk Pesticide initiative in 2005. After receiving registration, there has been great interest in use of aminopyralid in invasive plant control programs. Giant hogweed is a federal noxious weed of limited distribution in Pennsylvania and has been the target of intense eradication efforts since 1998. Herbicide trials in 2007, 2008 and 2009 at three different locations in Pennsylvania confirmed that aminopyralid controlled giant hogweed with or without triclopyr when applied to individual plants or in a broadcast spray.

EFFICACY OF AMINOPYRALID + METSULFURON ON SELECTED RANGE AND PASTURE WEEDS AND BRUSH. Byron B. Sleugh*, Mary B. Halstvedt, Pat L. Burch,Vernon B. Langston, Daniel C. Cummings, David E. Hillger, William N. Kline, Robert G. Wilson, Dow AgroSciences, Indianapolis, IN; University of Nebraska; Mark Renz, University of Wisconsin; Kevin Bradley, University of Missouri.

Aminopyralid (Milestone® specialty herbicide) is a new herbicide developed by Dow AgroSciences for managing noxious and invasive plants in range and pasture, rights-of-way, and other non-cropland sites. Aminopyralid has broad range activity on a number of key species and that spectrum is broadened even further when combined with certain other active ingredients. A new product with aminopyralid and metsulfuron (Chaparral™ herbicide) has been developed for use on rangeland, pastures, Conservation Reserve Program (CRP) land, and wildland. The maximum label rate for Chaparral is 2.02 oz ae/A (3.3 ounces product/acre). Field studies were initiated across several locations to determine efficacy of Chaparral on key target weeds in range and pasture including Canada thistle (*Cirsium arvense*), Musk thistle (*Carduus nutans*), buckbrush (*Symphoricarpos occidentalis* Hook. and *Symphoricarpos orbiculatus*) and common mullein (*Verbascum thapsus*), wild parsnip (*Pastinaca sativa*), wild carrot (*Daucus carota*) and others. Our data show that this combination of aminopyralid and metsulfuron has excellent efficacy on a broad spectrum of weeds and also allows for a more flexible time table for the control of certain weeds that typically have a narrow application window.

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CAN REDUCED RATES OF HERBICIDES AND LATE FALL TIMINGS CONTROL CANADA THISTLE IN ESTABLISHING PRAIRIES AND MAINTAIN FORB COVER? Brendon J. Panke, John W. Albright, and Mark J. Renz, Assistant Research Associate, Research Program Manager, and Assistant Professor, University of Wisconsin, Madison, WI 53706.

Public interest exists in establishing mixed forb grass prairie systems, but establishment can be reduced by weed populations, especially perennial weeds like Canada thistle (*Cirsium arvense*). While management of perennial weeds is best when implemented before prairie planting, often this is not the practice and resulting weed competition can reduce establishment of many planted species. Experiments were conducted at two such prairies in Horicon and McFarland Wisconsin to evaluate native forb and grass cover after fall applications of herbicide to suppress Canada thistle. Prairies had been planted one and two years prior to treatment at the McFarland and Horicon sites respectively. Treatments included 2,4-D (0.532 kg ae ha^{-1}), metsulfuron (12.6 g ai ha^{-1}), dicamba (0.56 kg ae ha^{-1}), glyphosate (0.28 kg ae ha^{-1}), aminopyralid (17.4 g ae ha^{-1} and 87.0 g ae ha^{-1}), and an untreated control. Plots were treated in September, early October, late October, and the McFarland site was also treated in late November. Late October and November application timings were after two and 16 instances of temperatures at or below 0°C were observed at both locations respectively, but earlier timings did not experience any freezing temperatures. Cover of Canada thistle was estimated for each plot the spring after treatment and again in the fall at both sites. During the October monitoring event, cover of native species was also visually estimated. Data for each treatment timing combination were analyzed by ANOVA, and if significant differences were detected, means were separated with LSD at $p<0.05$.

Reductions in spring Canada thistle cover were observed between treatment timing combinations at both sites with glyphosate in early October and both rates of aminopyralid in early and late October. By fall, only the 87.0 g ae ha^{-1} rate of aminopyralid at the late October timing showed any reduction at both sites. Reduced native forb cover compared to untreated areas was observed at the September timing for 2,4-D, metsulfuron, and dicamba at Horicon. The 17.4 g ae ha^{-1} rate of aminopyralid at the late October timing did show a trend of increasing native forb cover the most of all treatments when compared to untreated control at both sites. Differences in native grass cover that were consistent between the two sites were not observed. This research demonstrates that land managers have management options for native plantings that may not establish due to weed competition. Through careful selection of herbicide and application timing a land manager can both reduce the cover of unwanted species and increase the cover of native species.

EVALUATION OF FALL AND SPRING CONTROL METHODS ON GARLIC MUSTARD. Mark J. Renz, Brendon. J. Panke, Vijaikumar Pandian, Joyce Cielecki, and Steve Huntzicker. Assistant Professor and Assistant Research Associate, University of Wisconsin, Madison, WI 53706. Brown County Horticulture Extension Educator, Green Bay, WI 54302. La Crosse County Horticulture Educator and Assistant Professor, La Crosse, WI 54601.

As garlic mustard (*Alliaria petiolata*) continues to spread, interest exists in developing management strategies that can be implemented at various timings throughout the fall and spring as these timing prevent seed production and limit non-target plant injury. Research was conducted in understories of hardwood forests in three locations in Wisconsin to evaluate the effectiveness of herbicide application methods and rates for controlling garlic mustard and the response of other herbaceous vegetation present. Treatments consisted of individual plant treatments (IPT) with glyphosate in a 540 g ae L^{-1} formulation at 1% product solution, IPT with glyphosate at 2% product solution, broadcasted glyphosate at 0.84 kg ae ha^{-1}, broadcasted metsulfuron at 10.5 g ai ha^{-1}, and hand-pulled plants (late fall and late spring only). These methods were implemented in early fall before a frost, late in fall after several frosts, early spring just after garlic mustard germination, and late in the spring when garlic mustard is producing flowerbuds. Percent cover of garlic mustard and non-target vegetation were recorded in plots in June one month after late spring applications.

Treatments applied were effective in reducing adult garlic mustard plant cover, with few differences between timings. Reduced control with the 1% rate of glyphosate treated to individual plants was observed in the late fall and early spring at one site. In contrast, control with metsulfuron was consistent across timings at all sites. Hand-pulling garlic mustard in the fall significantly reduced cover the following summer only at one site, but was effective at two of the three sites when pulled in the late spring. Seedling garlic mustard plants were not controlled with any of the fall treatments except metsulfuron in the late fall at one site. All spring herbicide treatments nearly eliminated seedling cover. Hand pulling in the fall resulted in an increase in seedling cover the following spring at one site, but was effective at reducing seedling cover at all sites when conducted in the late spring. Resulting cover of resident non-garlic mustard herbaceous plants from treatments was variable between sites, with sites heavily infested with garlic mustard showing minimal response and medium and light infestations showing some injury depending upon treatment. In medium and light infested areas late fall and early spring herbicide treatments had the greatest herbaceous plant cover excluding garlic mustard. Results document a range of management options are available that are effective for garlic mustard management and if timed correctly management can enhance herbaceous plant cover.

SCOURINGRUSH IN NEBRASKA. Eric E. Frasure and Mark L. Bernards, Graduate Research Assistant and Assistant Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE 68583-0915.

Scouringrush is an increasing problem in some no-till fields in eastern Nebraska. The objective of this research was to identify effective methods for controlling scouringrush. Experiments were established on existing scouringrush patches in four separate studies in southeastern Nebraska between 2006 and 2008. Herbicides were applied using a backpack sprayer. In the first study we evaluated 14 herbicides labeled for use in corn, soybean or wheat. Only chlorsulfuron (53 g ai/ha) provided greater than 50% control. The second study used a split-plot design to measure the individual and combined effects of repeated mowing and nine different herbicide treatments. Mowing reduced biomass by 20% one year after the final herbicide application. Among the herbicide treatments, chlorsulfuron (158 g/ha followed by [f/b] 79 g/ha) was most effective and eliminated all stems one year after treatment. Imazapyr (560 g/ha f/b 1120 g/ha) and sulfometuron (210 g/ha f/b 420 g/ha) reduced scouringrush biomass 78% one year after treatment. The third study used a factorial design to evaluate tillage, herbicide, and crop competition effects. Repeated tillage controlled scouringrush only temporarily. Competition from dense stands of sorghum had an effect similar to repeated tillage one year after treatment. Chlorsulfuron (158 g/ha) controlled 90% of scouringrush one year after treatment. The fourth study compared additional herbicide treatments to tillage, mowing, and crop competition. The most effective herbicides were chlorsulfuron (158 g/ha) and dichlobenil (6700 g/ha). However, neither is labeled for use in corn or soybean. A greenhouse study was conducted to determine the effect of chlorsulfuron on corn and soybean growth when it is applied at rates necessary to control scouringrush. Both foliar and soil applied chlorsulfuron reduced corn and soybean height and biomass. Chlorsulfuron was the only treatment that completely controlled scouringrush, but it had an adverse effect on corn and soybean growth.

COMMUNITY OUTREACH: WORKING WITH GROUPS IN WEED CONTROL. Ed L. Fields, Director, Crawford County Weed Department Girard, KS 66743.

I was appointed weed director of Crawford County, Kansas in 2008 with very little money budgeted to my department. I was faced with an infestation of musk thistle on land that was in bankrupt proceedings, leaving little or no way to set any control in a timely method. Realizing that I had very few ways to solve this problem and knowing the boy scouts from my past, I set out on a different approach. Upon contacting the area scout master, we decided that a coordinated approach of education and harvesting the seed production would work to benefit both scouts and neighboring land owners. After orientating the scouts on the musk thistle and the reasons we need to control the problem, I received several questions that led to various weed related facts and information. I continued with a brief demonstration on how to harvest the seed heads. After three hours of harvesting we bagged 547 lbs. of thistle seed heads. This effort did not control the entire musk thistle problem but made a difference in the future seed production. The scouts received points for merit badges for participating and everyone benefited greatly.

Upon completing the boy scout project and publishing a subsequent article in the local newspaper, I was given an opportunity to work with the public regarding weed control with our local farm radio station's disc jockey. The program is called "Day with Dalton on the Farm". A phone call to the stations farm director and the landowner to coordinate a date and time was the first step. During the allowed live radio spots every 30 minutes, we harvested seed heads. After the radio show I received several calls from the general public who had been listening to this program in regards to musk thistle control.

Upon completing an inspection of a pasture in Farlington and finding musk & bull thistle, I contacted the land owner. The landowner informed me they had a medical condition called Encephalopathy (no tolerance of any chemicals.) Again I stepped outside the box and contacted the Girard High School Ag teacher and we worked out a program for his students to conduct a non-chemical approach to solve the problem.

In summary, the education regarding the appearance, growth patterns, and controlling process of Musk Thistle and Bull Thistle has been beneficial to all that participated. Education along with active community involvement, particularly the Boy Scouts of America and local agriculture students, has increased the awareness of the importance of noxious weed control.

I would like to thank the following for their contribution:
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Nina Criscuolo, Reporter KOAM-TV Pittsburg, Ks.

NAWMA-A TOOL FOR ON THE GROUND WEED MANAGERS. Riley G. Walters, Director, Butler County Noxious Weed Department, El Dorado, KS 67042

Eighteen years ago, county weed directors from Kansas, Nebraska, Colorado and Wyoming came together to form an organization called the North American Weed Management Association which is typically known as NAWMA. The purpose was to share information about invasive weeds and control strategies with the goals of increasing effectiveness and efficiency of control and raising awareness of the impacts of invasive plants.

A conference was held in Fort Collins, Colorado where Dr. George Beck and Dr. Phil Westra led tours of some of their work. A conference has been held annually since then in a different host state usually in late September. A goal of NAWMA has always been to equip members to recognize potential noxious weeds when they appear in their county and deal with them before they spread. Membership now also includes weed managers from Montana, Idaho, North and South Dakota, Washington, Arizona, New Mexico, Minnesota, Canada and Alaska.

Standards have been developed for certifying forage and gravel as weed free. Mapping standards have also been developed. Both mapping and forage standards are recognized and used by federal and state agencies. NAWMA has sponsored three Weeds Across Borders conferences and started National Invasive Weed Awareness Week in Washington, D.C., which this year is being incorporated into National Invasive Species Awareness Week (NIWAW), an all taxa event. NAWMA has joined the Healthy Habitats Coalition working with Wildlife Forever and other groups to hopefully be more effective in attracting funding for control of invasive species. Rob Headburg and Lee Van Wychen have been very helpful in coordinating the past events. The NIWAW conferences were very helpful in resolving problems with federal agencies.

NAWMA has a program to certify members as Invasive Plant Managers. It hopes to continue developing new services to assist those working to control invasive plants. We would welcome the opportunity to work with anyone who is involved with controlling invasive plants. Our website is **www.nawma.org**. It is being redesigned. The new version will be available after Jan. 1.

COOPERATING TO CONTROL HYDRILLA IN KANSAS. Jeffrey W. Vogel, State Weed Specialist, Kansas Department of Agriculture, Topeka, KS 66619.

Hydrilla is a federal noxious weed and considered one of the worst invasive aquatic weeds in the United States. It is an exotic submersed plant that is able to survive the harsh winters of the northern states. Currently, the Kansas Department of Agriculture (KDA) quarantines hydrilla which prevents the selling, bartering or transport of this plant and the Kansas Department of Wildlife (KDWP) and Parks classifies it as an Aquatic Nuisance Species. Prior to 2008, no wild infestations of hydrilla were reported in the State of Kansas.

During the summer of 2008, KDWP employees reported a wild infestation of hydrilla in an Olathe Park Pond that was later confirmed by the KDA and the United States Department of Agriculture. It was determined that the most likely source of hydrilla was an "aquarium dump" because several small pebble piles were located around the pond and that the infestation has been present from 2-4 years. Realizing that hydrilla was not required to be controlled by state law and considering the risk of this population spreading, a meeting was called between all interested parties to discuss a possible management plan. Attending the initial meeting in November of 2008 were representatives from the City of Olathe, KDWP, and KDA.

Produced from that meeting was a management plan that outlined a plan to monitor and control the established population with integrated methods, and survey for new infestations downstream. During the spring of 2009, we realized that not only was the pond infested with hydrilla but also curly leaf pondweed. This delayed the onset of the hydrilla until later in the summer when water temperatures increased. The City of Olathe provided a licensed applicator and applied granular floridone to the pond at the beginning of June and monitored the application throughout the summer. Floridone proved to be effective on all submersed weeds with no recreational, irrigation, or drinking water restrictions except the treatment was considerably expensive. To offset the City's expense, KDA provided the funds to purchase the herbicide through the Emergency Pest Fund which is funded by a five dollar fee added to each nursery business license. In addition, employees from KDWP and KDA survey downstream from the hydrilla infestation, once in July and again in late September. Results from the survey show that no hydrilla has established downstream from the pond. Biannual surveys will continue three years past the last known occurrence of hydrilla.

EVALUTATION OF NEW VENTURI NOZZLE DESIGNS FOR IMPROVING HERBICIDE EFFICACY. Robert E. Wolf and Dallas E. Peterson, Associate Professor and Extension Specialist, Biological and Agricultural Engineering, and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Field studies were conducted in 2008 and 2009 to evaluate herbicide efficacy comparing multiple nozzle types designed to reduce drift while maintaining adequate efficacy. The experiment included comparisons of a chamber style nozzle, the turbo flat-fan from Spraying Systems (TT): three older venturi styles, the AirMix from Greenleaf (AM), the Ultra LoDrift from Hypro (ULD), and the Air Induction from TeeJet (AI); two new venturi style nozzles, the Air Induction Extended Range from TeeJet (AIXR) and the Guardian Air from Hypro (GA); a new design chamber nozzle, the Turbo Twin flat-fan from TeeJet (TTJ60), and a new venturi design from Greenleaf, a TurboDrop High Speed Twin Fan (TD HS TF). In 2009, another new nozzle design was added, the air induction twin flat-fan from Lechler (IDK-T). Orifice sizes and operating pressures (.03 at 193 kPa, .025 at 276 kPa and .02 at 483 kPa) for each nozzle treatment were selected to deliver a spray volume of 70 L/ha at 16 km/h. The orifice sizes were TT110025, AM110025, TTJ60110025, GA110025, AIXR110025, AIC11002, ULD12002, TDHSTF11002, and IDK-T12003. Applications were made with a tractor-mounted 3-point sprayer equipped with four nozzles spaced at 51 cm and located 51 cm above the target. For both years, glyphosate at 0.42 kg ae/ha and paraquat at 0.42 kg ai/ha were used to compare efficacy. In 2008 the species used for the comparisons were velvetleaf, common sunflower, sorghum, and corn. In 2009, velvetleaf, ivyleaf morning-glory, sorghum, and corn were used for the comparisons. N PAK ammonium sulfate at 5% v/v was added to the glyphosate treatments and nonionic surfactant at 0.5% v/v was added to the paraquat treatments. Both years the treatments were replicated three times and efficacy was evaluated at 7, 14, and 28 days after treatment with 28 DAT reported.

Species control varied between glyphosate and paraquat for both years. When averaged across nozzle type and species in 2008; glyphosate had 96.2% control and paraquat had 80.2% control, compared to 83.4% and 69.2% in 2009 respectively. Within the compared species, glyphosate had very few differences in control among nozzle types for either year. Range of control averaged across nozzle type by species was 99.8% for corn, 99.6% for sorg, 98.4% for cosf, and 86.8% for vele in 2008. In 2009, the same averages were 98.2% for sorg, 89.4% for corn, 81.1% for vele, and 64.7% for ilmg. With paraquat, in both years mixed results with some differences were found across all nozzle types and species. Range of control in 2008 averaged across nozzle type by species was 93% for cosf, 83.5% for corn, 73.3% for vele, and 71.0% for sorg. Control in 2009 ranged from 85% for vele, 84% for ilmg, 69.2% for corn, and 38.4% for sorg. In 2009, for the paraquat treatments, the broadleaf species control was much better than the grass species control.

For both years there were no significant differences found for each species among nozzle types when averaged across glyphosate and paraquat. In 2008, the average control across nozzle type was 96% for cosf, 92% for corn, 85% for sorg, and 80% for vele. In 2009, average control across nozzle type was 83% for vele, 79% for corn, 74% for ilmg, and 69% for sorg.

In summary, for the glyphosate treatments across all species tested and nozzle types, though only slight differences were found, the AIXR (85.5%) and TT (85.3%) exhibited the best control. When comparing similar nozzle designs, the twin-fan IDK-T (84.3%) performed better than the twin-fan TTJ60 and TDHSTF (both 82%). Within the new venturi designs, the AIXR (85.5%)

outperformed the AM (83%) and GA (83.3%). For the old style venturi designs, the AIC and ULD performed the same (82.5%).

For the paraquat treatments across all species and nozzle types, the twin-fan TTJ60 had the best control (73.8%), the IDK-T, also a twin-fan, was next with 72%. The AIC was third (70.3%), followed by the AIXR (69.8%) and the AM (69.0%). The TDHSTF (67.8%), ULD (67.5%), TT (66.3%), and the GA (66.3%) had the lowest control with paraquat. When comparing similar designs, with the twin-fan designs, the TTJ60 and IDK-T outperformed the TDHSTF. The single outlet TT was outperformed by the double outlet TTJ60 (73.8 – 66.3%). With the new style venturi designs, the AIXR and AM performed better than the GA. For the old style venturi designs, the AIC performed better than the ULD.

FACTORS AFFECTING SPRAY DISTRIBUTION AND COVERAGE. Gregory K. Dahl, Joe V. Gednalske, and Eric Spandl Research Manager, Manager of Product Development and Agronomist, Winfield Solutions LLC, St. Paul, MN 55164.

The demand for reducing risks from herbicides has focused attention on reducing off target movement of herbicides with drift reducing technologies (DRT). It is important to minimize spray drift, but it is equally important to make sure that the herbicide performs satisfactorily. Many technologies were used to evaluate changes in spray distribution and drift reduction. Spray droplet size was the most important factor influencing spray drift.

Field studies and laser droplet analysis were done with various nozzle types, sizes and spray pressures. Spray mixtures included water alone or glyphosate, glufosinate and other herbicide mixtures. A modified vegetable oil deposition aid and drift control adjuvant or a guar-type adjuvant was added to the water or herbicide mixtures. Spray patterns were recorded with a high-speed video camera and played back in slow motion to demonstrate droplet distribution and movement. Field evaluations were done by applying treatments in windy conditions and measuring distance of movement downwind.

Nozzles, spray mixtures, and wind significantly impacted results. The proper nozzle and a drift reducing adjuvant significantly reduced the amount of fine droplets.

HIGH SURFACTANT OIL CONCENTRATES - THE REST OF THE STORY. Richard K. Zollinger, Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58108.

Glyphosate is a highly hydrophilic herbicide and require surfactant type adjuvants to enhance phytotoxicity. Many postemergence herbicides applied with glyphosate to increase weed control are lipophilic (clethodim, tembotrione, others) and require oil type adjuvants for optimum weed control. Adjuvant selection when tank-mixing glyphosate and lipophilic herbicides may enhance or antagonize either herbicide. Surfactants are less effective in enhancing lipophilic herbicides and oil adjuvants, including crop oil concentrates (COC) and methylated seed oil (MSO), may antagonize glyphosate. High surfactant oil concentrates (HSOC) were developed to enhance lipophilic herbicides without antagonizing glyphosate. HSOC adjuvants by ASTM definition contain at least 50% w/w oil plus 25 to 50% w/w surfactant. Field trials were conducted in 2009 to compare commercial HSOC adjuvants. Flax, quinoa, tame buckwheat, and corn were planted as assay species. Glyphosate and clethodim were applied alone, and with nonionic surfactant, COC, MSO, an oil based surfactant: Trophy Gold, and the following HSOC adjuvants: Between, Diplomat, Exchange, High Load, Superb HC, Destiny HC, and PX40802. All treatments were applied with and without ammonium sulfate (AMS), and applied perpendicular to assay species. All HSOC adjuvants are not created equal. HSOC adjuvants ranked in order of highest to lowest in activating glyphosate plus clethodim is: Destiny HC>PX40802>Suberb HC=Trophy Gold>Diplomat=Exchange=High Load. Addition of AMS at 8.5 lb/100 gal water enhanced all treatments but relative level of control generally remained similar to treatments applied without AMS. Trophy Gold plus AMS showed a higher increase in control than other treatments with AMS and was similar to Destiny HC for most assay species. PX40802 showed the least response to AMS. Some HSOC adjuvants enhanced weed control from the lipophilic herbicide clethodim and also enhanced broadleaf weed control from glyphosate. Addition of AMS enhances phytotoxicity from all adjuvants applied with glyphosate plus clethodim but does not completely overcome antagonism from oil adjuvants applied with glyphosate.

USING CLICKERS TO TEACH CALIBRATION OF SPRAYERS. Robert N. Klein, Western Nebraska Crops Specialist, University of Nebraska West Central Research and Extension Center, North Platte, NE 69101.

Applying the correct rate of a product is an important part of obtaining good results with pesticides. With a pesticide application, too little product can mean poor control, while too much can result in crop injury, extra costs, possible residue on the crop, and carryover.

Many methods can be used to calibrate sprayers, including the ounce calibration and formula-based methods. With the ounce calibration method, 1/128 of an acre is sprayed and the spray is collected. When measured in ounces the amount would be equal to the number of gallons applied per acre since there are 128 ounces in a gallon. Other methods involve using formulas which need to be remembered or recorded for easy use. These methods also may require converting some of the information you have.

The methods discussed in this presentation are simple relationships and do not require remembering formulas. However, you do need a general understanding of cross multiplication. The important thing is to be consistent: if you put an item on the top of an equation on one side, the same item also goes on the top of the other side.

Three factors that determine sprayer application rate are: 1) Speed, 2) Nozzle spacing, 3) Nozzle output (determined by orifice size, pressure, and density of spay solution).

A NebGuide which illustrates this method, G1511 “Calibration of Sprayers (Also Seeders)” is available on the University of Nebraska Web Site at http://ianrpubs.unl.edu/farmpower/

Using clickers enables the instructor to quickly measure the learning level of the participants. The instructor then knows if one should spend additional time on an area or can proceed to the next area. Following are examples of questions used to measure the participants progress.

Question 1. What is the travel speed if we travel 388 feet in 23 seconds?

a. 5.5 mph, b. 7.5 mph, c. 9.5 mph, d. 11.5 mph

Question 2. What is the gallons per acre if we collect 48 ounces in 30 seconds with a travel speed of 10 mph with 30” nozzle spacing?

a. 14.85 gpa, b. 16.25 gpa, c. 18.5 gpa, d. 20.65 gpa

Question 3. If I want to apply 10 gpa with an 11006 Al nozzle tip at 50 psi and I have 30” nozzle spacing, what is the speed?

a. 9.3 mph, b. 11.3 mph, c. 13.3 mph, d. 15.3 mph

Based on responses obtained from participants, the instructor may decide to review topics such as cross multiplication and/or using information from sprayer calibration references.

IT'S A SURE THING…PROBABLY: THE INFLUENCE OF VARIABILITY ON TRIAL PLANNING, DESIGN AND ANALYSIS. Leslie Fuquay, Syngenta Crop Protection, Research Triangle Park, NC.

Graduate students and other researchers are often occupied with specific, comprehensive and complex statistical analyses of their project data. As horizons broaden and career paths advance, it is important not to lose sight of statistical fundamentals. Using objective-based trial planning and design, reducing experimental error and facilitating valid classification of the remaining error will lead to better experiments, less ambiguous outcomes and more straightforward interpretation.

TRADITIONS AND CONVENTIONS IN THE USE OF REPEATED MEASURES ANALYSIS, CONTRAST, AND PAIRWISE COMPARISONS. Chris Reburg-Horton, North Carolina State University, Raleigh, NC.

Part of the appropriate application of statistics is not covered in textbooks. Each discipline carries its own traditions and conventions in the use of statistics. We will discuss those traditions in our field and how they intersect with what is taught in the statistics classroom. Utilizing examples from Weed Science, we will walk through appropriate and inappropriate uses of statistics. The session will focus on fundamental statistical issues such as repeated measures, contrasts, and pairwise comparisons.

SQUEEZING MORE INFORMATION OUT OF YOUR DATA. Adam Davis, USDA-ARS, Champaign, IL.

Statistical analyses of weed data sets often use analysis of variance to quantify treatment effects on weed growth and interference with crop yield. While ANOVA is a powerful tool, and a good entry point into a data set, its value can be greatly enhanced when related environmental and plant growth parameters are used to explore mechanisms underlying treatment effects.

A "HANDS-ON" WORKSHOP – STATISTICAL CROSS-TRAINING: TRIAL DESIGN, BLOCKING AND SAMPLING. Leslie Fuquay, Syngenta Crop Protection, Research Triangle Park, NC.

In a hands-on, team environment, see how much you know, or recall, about laboratory, greenhouse and field trial design, blocking and sampling. Exercises represent general trial layout tasks across a variety of disciplines and objectives.

DETERMINATION OF TANK-MIXTURE EFFICACY. Stott Howard, Syngenta Crop Protection, Des Moines, IA.

Although Colby's method has been widely studied and serves as an important industry benchmark for determining the type of interaction when two herbicides are used in mixture, it does lack a suitable method for statistical analysis. Flint's analysis provides a statistical test for additive, synergistic, and antagonistic effects. By using the effects of the herbicides when applied alone, Flint's analysis calculates 'expected' values for additivity and then tests for significant differences between the calculated and measured values of the herbicide mixture. A strength of this statistical test is that a range or series of rate combinations may be tested for significant interactions simultaneously, and a weakness of this analysis is that low rates of both herbicides are required to provide accurate calculations of expected values.

HYDRILLA AND OTHER INVASIVE AQUATIC PLANTS. William T. Haller, Professor and Acting Center Director, Center for Aquatic and Invasive Plants, Department of Agronomy, University of Florida, Gainesville, FL 32653.

Dioecious hydrilla was introduced into Florida as an aquarium plant in the 1950s and was widely planted in natural waterbodies for subsequent collection and sale. Naturalized populations of monoecious hydrilla, a distinct biotype of the species, were first discovered in the Virginia/Maryland area in the early 1980s, but the date of introduction of monoecious hydrilla is unknown. Both biotypes of hydrilla have spread rapidly throughout the United States since their introductions, with invasions reported from Maine to Washington State and from Florida north to Indiana and Wisconsin.

The biotypes of hydrilla are physiologically very different from one another. For example, monoecious hydrilla in the northern part of the US sprouts from tubers and turions during May, June and July; plants produce vegetative propagules during late summer and fall and senesce in late fall and winter, resulting in growth patterns similar to annual species. In contrast, dioecious hydrilla produces hundreds of tubers and turions between September and May when short-day conditions predominate and is considered a perennial in the southern part of its range. Despite these differences, both biotypes of hydrilla respond to herbicides in a similar manner.

Hydrilla is uniquely adapted to low light conditions and grows in Florida lakes at water depths that native submersed plants are unable to survive. This often results in expansion of the vegetated littoral zone from 10 to 20% in shallow Florida lakes to coverage that exceeds 80% of the lake’s area. Florida state agencies have spent $210 million during the last decade to control 400,000 acres of hydrilla ($525 per acre) to maintain recreational and ecological functions of Florida lakes.

Hydrilla should be a concern to authorities in mid-America; however, this region is threatened by other invasive aquatic weeds as well. Parrotsfeather, waterchestnut, egeria and flowering rush have been present in the eastern US for decades and are migrating west. In addition, more recent introductions of species such as watersoldier (*Stratiotes aloides*) and European frog’s-bit (*Hydrocharis morsus-ranae*) into the Great Lakes area (New York State/Ontario) pose additional threats to this part of the country.

PURPLE LOOSESTRIFE: BIOLOGY AND MANAGEMENT OPTIONS. Stevan Z. Knezevic, Associate Professor, University of Nebraska, Concord, NE 68728-2828.

The introduction and spread of exotic plant species is one of the most serious threats to biodiversity. Purple loosestrife (*Lythrum salicaria*) is one such species that is currently invading wetlands and waterways in Mid-Plains states including an estimated 12,000 acres in Nebraska. Once a wetland is taken over by purple loosestrife, the natural habitat is lost and the productivity of native plant and animal communities is severely reduced. A series of field studies were conducted from 2000 to 2009 at three locations in Nebraska with the objective to evaluate performance of 14 herbicide treatments, mowing, and disking. In general, excellent two to three year long control was achieved with glyphosate, imazapyr, or metsulfuron applied alone. Imazapyr treatments however caused detrimental effects to the native vegetation, especially grassy species, indicating limited use of that treatment. Repeated disking that was conducted three times per season in semidry areas and over a five year period provided much better control than repeated mowing.

SERICEA LESPEDEZA: BIOLOGY AND MANAGEMENT OPTIONS. Walter H. Fick, Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Sericea lespedeza [*Lespedeza cuneata* (Dumont) G. Don] is a federally listed forage crop planted primarily in the southeastern U.S. and often used in mine land reclamation. However, sericea lespedeza has become an invasive species in grasslands throughout portions of the central and southern Great Plains. Sericea lespedeza is often unpalatable to cattle because of high tannin content that increases with plant maturity. Tannins tie up protein and negatively impact digestibility of the forage. Given a choice, cattle typically avoid sericea lespedeza allowing the species to increase over time. Increasing populations of sericea lespedeza can reduce forage production and species diversity. The species was declared as a state-wide noxious weed in Kansas in 2000 and currently infests over 240,000 ha in the state. Sericea lespedeza is a perennial legume native to eastern Asia. Seeds can germinate any time during the growing season under favorable conditions, but seedlings are most frequently noted during the late spring and early summer. The trifoliate leaflets are wedge-shaped. Plants generally do not flower until the second growing season. Mature plants are erect in stature, often with branched stems, and grow to a height of 0.5 to 2 m. Flowering occurs from late July until early October. Sericea lespedeza has both cleistogamous and chasmogamous flowers. The flowers are white to creamed colored with a purple throat. A single plant can produce more than 1,000 seeds. Dense stands of sericea lespedeza are known to have a seed bank in excess of 100 million seeds per ha. Sericea lespedeza produces a deep taproot making it drought tolerant once established. Sericea lespedeza grows best in full sunlight but is shade tolerant. The photosynthetic rate of sericea lespedeza is about half that of alfalfa and it is less water-use efficient than most other warm-season species. Total nonstructural carbohydrates (TNC) stored in the root/crown decline during spring growth and reach a secondary low-point at the flower bud stage. Subsequently, root/crown TNC increases during flowering and seed production. Crown buds are produced in the late summer.

Options to consider for management of sericea lespedeza include biological, grazing, mechanical, prescribed burning, and chemical approaches. Lespedeza webworms and root-knot nematodes can provide some reduction in seeds and stunted plant growth, but do not appear to provide reliable biological control. Sheep and goats will consume sericea lespedeza, but high stocking rates are needed to prevent seed production. Supplementing cattle with polyethylene glycol (PEG) increases consumption of sericea lespedeza but problems with consumption, cost, and labeling reduce the potential use of PEG. Repeated mowing during the summer will decrease stands of sericea lespedeza and may prevent seed production. Prescribed burning in the late spring generally stimulates seed germination and increases stem density. Late summer or fall burns have been shown to suppress sericea lespedeza. A number of herbicides have been screened over the years to determine their efficacy in controlling sericea lespedeza. Herbicides that are commonly used on grasslands including 2,4-D, dicamba, and picloram are not effective in controlling sericea lespedeza. Products containing triclopyr, metsulfuron, and fluroxypyr have proven to be the most effective. Spot treatment of sericea lespedeza with glyphosate is also effective. Long-term grazing with goats or an integrated approach using prescribed burning, grazing, and chemical control seem to be the most effective management strategies for coping with sericea lespedeza at this time.

SPOTTED KNAPWEED AND OTHER *CENTAUREA'S*: BIOLOGY, DISTRIBUTION, AND MANAGEMENT. Celestine A. Duncan, Consultant, Weed Management Services, PO Box 1385, Helena, MT 59624.

The genus *Centaurea* includes 37 weedy species in the United States, of which spotted knapweed, diffuse knapweed, and yellow starthistle are the most problematic. These three species are well adapted to a wide range of habitats including open forests, rangeland, wildland, roadsides, pastureland, riparian areas, and ditch banks. Yellow starthistle is native to southern Europe and western Eurasia. The weed was introduced into California about 1869 and is currently reported in 41 of 50 states infesting 14.8 million acres in the U.S. More than 98% of existing infestations occur in California, Idaho and Oregon. Diffuse knapweed is native to grassland and shrub steppes of eastern Mediterranean and western Asia, and was first reported in western North America in 1907. In the United States, the primary range of diffuse knapweed is western states including Oregon, Washington, Idaho, and Colorado that report 1.8 million acres or 99% of infested acres nationwide. Of the three species, spotted knapweed is the most problematic across the U.S. and is currently reported in all states except Alaska, Texas, Oklahoma and Mississippi. Spotted knapweed was introduced to the Pacific Northwest from Europe in 1893, and currently infests 6.9 million acres in the United States. About 75% of infested acres occur in Montana, Idaho, Oregon, and Washington with significant infestations reported in the Midwest including Kentucky, Michigan, Minnesota, Missouri, and Wisconsin. This abstract will focus on biology and management of spotted knapweed since it is the greatest concern in North Central states.

Spotted knapweed is a non-native, tap-rooted, biennial or perennial forb that can live at least 9 years. The weed reproduces entirely from seed. Seed production ranges from 465 to 3,716 seeds/ft^2, or about 1,000 seeds per plant under rangeland conditions. Seeds can survive in soil for at least 8 years and are dispersed by wildlife, livestock, humans and their vehicles, as contaminants in crop seed and hay, and by flowing water. Spread rate across the U.S. ranges from 10 to 24% annually. The plant is adapted to a wide range of environmental conditions and has been reported at elevations ranging from 98 to 9,000 ft and in precipitation zones ranging from 10 to 30 inches.

Management requires an integrated approach utilizing prevention, herbicides, biological control agents and grazing animals. There are several herbicides available to effectively control spotted knapweed and land mangers should consider site conditions and label guidelines when choosing a herbicide. Aminopyralid at 1.25-1.75 oz ae/ac, clopyralid at 4 to 6 oz ae/ac, and picloram at 4 to 6 oz ae/ac provides excellent control of spotted knapweed (and other invasive *Centaurea's*) for up to two years following treatment. Application of 2,4-D at 32 oz ae/ac and dicamba at 8 to 16 oz ae/ac will provide fair to good control of spotted knapweed for one year following treatment. Adding 2,4-D to dicamba will increase control over dicamba alone.

Cultural control includes livestock grazing, fire, and seeding desirable vegetation. Clipping spotted knapweed (either mowing or with livestock) at late bud growth stage will reduce seed production, but may not impact weed density. Hand pulling will effectively control knapweed; however it is cost prohibitive on most sites. Prescribed burning has generally been ineffective for controlling knapweeds, and may increase weed density. Establishing desirable perennial plant communities following treatment of either knapweed or starthistle is critical to maintaining long term control.

Introduction of biological agents has effectively reduced populations of spotted and diffuse knapweed. Significant reductions in spotted knapweed density has been recorded in Montana largely due to combination of effects of a root weevil (*Cyphocleonus*) on mature plants, and three seed head insects (*Larinus minutus, L. obtusus,* and *Urophora affinis*) on knapweed soil seed bank. Significant reductions of diffuse knapweed have occurred in the Pacific Northwest due primarily to the seed head weevil *Larinus minutus*. Insects alone and combined with other management methods may prove cost effective for long term management of knapweed.

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EVALUATING THE UTILITY OF GLUFOSINATE FOR WEED MANAGEMENT IN BURNDOWN APPLICATIONS. Mark A. Waddington, Jayla R. Allen, Michael Weber, Bayer CropScience, RTP, NC 27709.

Some growers are struggling with hard to control weeds in burndown applications of glyphosate. Glyphosate resistant horseweed (*Conyza canadensis*) has been confirmed and continues to be troublesome in traditional corn and soybean rotations throughout the Midwest. Glufosinate has proven successful in burndown applications prior to cotton, and has received a label utilizing glufosinate for burndown applications prior to corn or soybeans. Trials were conducted by Bayer CropScience and universities across the Midwest to evaluate the utility of glufosinate alone or in tank mixtures for burndown situations. Glufosinate provided control of most weeds, including glyphosate resistant horseweed.

EVALUATION OF PROGRAMS FOR THE MANGAGEMENT OF PALMER AMARANTH AND COMMON WATERHEMP IN CONVENTIONAL, GLYPHOSATE-RESISTANT, AND GLUFOSINATE-RESISTANT SOYBEANS. Kristin K. Payne*, Eric B. Riley, Travis R. Legleiter, Jim D. Wait, and Kevin W. Bradley, Graduate Research Assistant, Research Specialist, Senior Research Specialist, Research Associate, Associate Professor, Division of Plant Sciences, University of Missouri, Columbia, MO 65211.

Separate field experiments were conducted in central and southeast Missouri during 2009 to evaluate the effect of preemergence (PRE) and postemergence (POST) herbicide programs on palmer amaranth (*Amaranthus palmeri* S. Wats.) and common waterhemp (*Amaranthus rudis* Sauer) control in conventional, glyphosate-resistant, and glufosinate-resistant soybean (*Glycine max*) production systems. At both sites, Schillinger 388TC, Asgrow AG3803 glyphosate-resistant, and MBS Genetics ML3963N glufosinate-resistant soybeans were planted at approximately 370,000 seed/ha. Palmer amaranth was the predominant species at the southeastern research location while common waterhemp was the predominant species at the central research location. Treatments included PRE-only, PRE fb POST, 2-pass POST, 1-pass POST with residual, and 1-pass POST herbicide programs relevant to the respective transgenic or non-transgenic soybean system. Results from visual control evaluations ten weeks after emergence (WAE) at the central location revealed that all PRE-only and PRE fb POST applications provided greater than 97% common waterhemp control in either soybean system, while the 2-pass POST programs provided 76 to 92% common waterhemp control, and the 1-pass POST and 1-pass POST with residual programs were more variable and provided only 53 to 78% common waterhemp control. At the southeast research location, all PRE-only applications provided greater than 84% palmer amaranth control across soybean systems, while PRE fb POST applications provided from 63 to 89% palmer amaranth control, and 1-pass POST, 2-pass POST, or 1-pass POST with residual programs were extremely variable. Palmer amaranth control with POST programs in conventional soybeans ranged from 9 to 23% while 2-pass POST programs in glyphosate and glufosinate-resistant soybeans provided 89 to 98% control. The 1-pass POST program in glyphosate-resistant soybeans provided 67% palmer amaranth control but control was increased to 95% with the 1-pass POST with residual program. In glufosinate-resistant soybeans, the 1-pass POST with residual program did not increase palmer amaranth control compared to the 1-pass POST program. These results suggest that palmer amaranth is a much more difficult species to control than common waterhemp, regardless of the soybean system or herbicide program. Averaged across all herbicide programs at the central and southeast research locations, glufosinate-resistant soybeans provided the highest grain yields (4205 kg/ha central, 2801 kg/ha southeast) followed by the glyphosate-resistant soybean system (3795 kg/ha central, 2615 southeast) and the conventional soybean system (3227 kg/ha central, 1845 kg/ha southeast). Collectively, the results from both trials indicate that programs containing PRE herbicide treatments provide the best opportunity for season-long control of common waterhemp and palmer amaranth and optimum grain yields in conventional, glyphosate-resistant, or glufosinate-resistant soybean systems.

OPTIMUM® GAT® CROPS – HERBICIDE PROGRAMS WITH BURNDOWN PLUS RESIDUAL ACTIVITY FOR NO-TILL CROPPING SYSTEMS. David W. Saunders*, Susan K. Rick, Marsha J. Martin, and Richard M. Edmund, Product Development Manager, DuPont Crop Protection, Johnston, IA 50131.

Weed control programs designed for use in no-till cropping systems for corn and soybeans containing the Optimum® GAT® trait are under development. Integrated herbicide programs making use of burndown, preemergence, and postemergence weed control strategies were evaluated by DuPont, university, and contract investigators in 2009. Data will be presented supporting the use of herbicides designed for use on Optimum® GAT® trait crops as new tools for managing weed control problems in reduced tillage fields across the North Central States. Seed products with the Optimum® GAT® trait will be available for sale pending regulatory approvals and field testing. New DuPont herbicides for the Optimum® GAT trait® are not currently registered for sale or use in the United States.

OPTIMUM® GAT® SOYBEANS – HERBICIDE PROGRAMS FOR THE NORTH CENTRAL STATES. Mick F. Holm*, James D. Harbour, Helen A. Flanigan and David W. Saunders, Product Development Representative, DuPont Crop Protection, Johnston, IA 50131.

Weed control programs designed for use on soybeans containing the Optimum® GAT® trait are under development. Integrated herbicide programs making use of preemergence, postemergence, and 2-pass weed control strategies were evaluated by DuPont, university, and contract investigators in 2009. Data will be presented supporting the use of Optimum® GAT® trait crops as new tools for managing weed control problems including herbicide resistance weeds across the United States. Seed products with the Optimum® GAT® trait will be available for sale pending regulatory approvals and field testing. New DuPont herbicides for the Optimum® GAT® trait are not currently registered for sale or use in the United States.

REGIONAL SUMMARY OF OPTIMUM GAT SOYBEAN RESEARCH. Angela J. Kazmierczak, Richard K. Zollinger, Chris M. Boerboom, Michael Moechnig, and Tom Hoverstad; North Dakota State University, Fargo, ND 58108; University of Wisconsin, Madison, WI 53706, South Dakota State University, Brookings, SD 57007, University of Minnesota, Waseca, MN 56093.

Optimum GAT (glyphosate acetolactate tolerance) technology allows glyphosate and various ALS herbicides to be applied for weed control while maintaining safety to transformed crops. Experiments were established at four locations across the upper Midwest to determine soybean crop safety and efficacy of the herbicide programs designated for the technology: Arlington, WI; Waseca, MN; Brookings, SD; and Prosper, ND. Treatments were applied to Optimum GAT soybean and included either PRE followed by POST or POST applications of the following: clorimuron, thifensulfuron, flumioxazin, glyphosate, tribenuron, rimsulfuron, cloransulam, and sulfentrazone. Herbicide rates were determined within the labeled rates. Across all locations, there was a wide spectrum of weeds evaluated, but specific species varied by location. Crop safety was evaluated at most locations and injury to soybean was not observed. Overall, treatments provided greater than 90% control of all weeds at the last evaluation timing with the exception of common ragweed at Propser where treatments that received only a POST application gave 86 to 88% control.

ESTABLISHMENT OF SWITCHGRASS FOR BIOFUEL PRODUCTION IN WISCONSIN. Mark Renz, Assistant Professor, University of Wisconsin, Madison, WI 53706.

Establishment of switchgrass can be reduced by weeds, but few studies have evaluated the effectiveness of herbicide treatments applied pre (PRE) or post-emergent (POST) in improving switchgrass establishment and productivity. Two experiments were established at Marshfield, Wisconsin to evaluate the benefit of PRE or POST herbicide applications as randomized complete block design with three replications. PRE herbicide treatments consisted of imazethapyr (35 and 70 g ae ha^{-1}), imazamox (17.5 and 35 g ae ha^{-1}), imazapic (70 g ae ha^{-1}) + glyphosate (140 g ae ha^{-1}), quinclorac (420 and 840 g ai ha^{-1}), dithiopyr (280 and 560 g ae ha^{-1}), sulfosulfuron (840 and 1680 g ai ha^{-1}), glyphosate (840 g ae ha^{-1}), and an untreated control. POST treatments were applied when switchgrass had 2-3 true leaves and included both rates of imazethapyr, imazamox, sulfosulfuron, and quinclorac as the PRE experiment as well as imazapic (70 g ha^{-1}), 2,4-D (1064 g ae ha^{-1}), dicamba (280 g ae ha^{-1}) + 2,4-D (785 g ae ha^{-1}), metsulfuron (4.2 g ai ha^{-1}), and an untreated control. Adjuvant was added to all POST treatments based on manufacturer recommendations for each herbicide. Percent cover of switchgrass and grass (primarily *Setaria* and *Digitaria* spp.) and broadleaf weeds (primarily *Chenopodium album* and *Amaranthus* spp.) were estimated in July and September during the establishment year and above ground dry biomass was estimated within plots in the establishment and two subsequent years.

In the PRE trial, broadleaf weed cover was reduced compared to untreated plots by all treatments except quinclorac and glyphosate 50 days after treatment (DAT), but only 2,4-D, metsulfuron, 2,4-D + dicamba, imazamox at 17.5 g ha^{-1}, and sulfosulfuron at 840 g ha^{-1} reduced broadleaf cover by the same date (20 DAT) in the POST trial. Low grass weed populations in the field resulted in no treatments with less cover than untreated plots in either trial. Although stunting of switchgrass was observed in treatments with imazethapyr, imazamox, imazapic, dithiopyr, sulfosulfuron, and metsulfuron, by September only PRE dithiopyr treatments had less switchgrass cover than untreated plots in either trial. Switchgrass cover in September of the establishment year was increased two to three fold with PRE treatments of imazethapyr, imazamox, imazapic + glyphosate, and sulfosulfuron at 840 g ha^{-1} and POST treatments of 2,4-D, metsulfuron, 2,4-D + dicamba, and dithiopyr compared to untreated plots. Dry biomass of switchgrass in the establishment year was increased two to fourfold with imazapic and imazamox at 35 g ha^{-1} treated PRE and 2,4-D and 2,4-D+dicamba treated POST compared to untreated plots which yielded 0.5 and 0.7 Mg ha^{-1} in PRE and POST trials respectively. The year following establishment biomass was greater than untreated plots in PRE treatments of imazamox, imazethapyr, glyphosate + imazapic, and sulfosulfuron at 840 g ha^{-1} and the POST treatments of metsulfuron, 2,4-D, and 2,4-D+dicamba. These treatments doubled aboveground biomass compared to untreated plots which yielded 5.0 and 4.5 Mg ha^{-1} in PRE and POST trials respectively. Two years after establishment, only glyphosate + imazapic and metsulfuron continued to show greater biomass than untreated plots with yields of 10.3 and 8.8 Mg ha^{-1} respectively. Results suggest that weed management during establishment can improve cover and productivity in the establishment and two subsequent years.

TOLERANCE OF SWITCHGRASS TO PRE- AND POSTEMERGENCE HERBICIDES. Wesley J. Everman*, Calvin F. Glaspie, Demitria Gavit, Jan Michael, and Donald Penner. Michigan State University, East Lansing., Assistant Professor, Graduate Research Assistant, Field Research Assistant, Research Technician and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824-1325.

The increased interest in using native grasses such as switchgrass (*Panicum virgatum*) as a renewable energy source for cellulosic ethanol production raises several questions about best production practices. Currently no herbicides are labeled for use in switchgrass production; however weed control products need to be evaluated for potential use as production practices develop. Studies were established in 2008 and 2009 at Michigan State University in East Lansing, MI to determine the effect of pre- and postemergence herbicides on switchgrass growth and biomass. Switchgrass varieties ‘Alamo’ and ‘Cave-in-Rock’ were evaluated utilizing a randomized complete block arrangement of treatments. Pre- and postemergence herbicides were chosen based upon grass crop tolerance. Crop injury, height and stage measurements were taken weekly following herbicide application. Varieties showed few differences in injury response to herbicides, however growth differences were observed at the end of the study. Atrazine and quinclorac treatments resulted in the least injury, with all other preemergence herbicides causing significant injury. Several postemergence herbicides, primarily growth regulator and photosystem inhibitors, were safe on switchgrass. Injury from postemergence herbicides was greatest with ALS and HPPD inhibiting herbicides.

A COMPARISON OF FULL-, SPLIT- AND MICRO-RATE HERBICIDE TREATMENTS FOR WEED MANAGEMENT IN RED BEET. Darren E. Robinson, Associate Professor, Department of Plant Agriculture, University of Guelph, Ridgetown Campus, Ridgetown, ON, N0P 2C0.

Trials were established in 2008 and 2009 at different locations each year to determine red beet tolerance and weed control of pyrazon plus triflusulfuron applied as full, split or micro-rates, with or without a preemergence application of s-metolachlor (1200 g ai/ha). In 2009, visual injury was observed in the split-rate and micro-rate treatments, and corresponded to reductions in yield of No.1 and 2 beets where s-metolachlor had been applied PRE, and where split-rates of pyrazon plus triflusulfuron were applied. These results were in contrast to those observed in 2008, where no injury or yield reductions were observed ($p<0.001$). The primary difference between the trials was higher soil OM (9.2 vs. 3.2%) and lower sand content (49 vs 78%) in 2008 than in 2009. All treatments that included pyrazon plus triflusulfuron applied as split- or micro-rate applications provided greater than 90% control of common lamb's-quarters and redroot pigweed. In years or fields where multiple flushes of weeds occur, the best weed control is obtained with the use of micro-rates.

EFFECT OF GLYPHOSATE DRIFT DROPLET CONCENTRATION TO IRRIGATED POTATOES. Harlene M. Hatterman-Valenti and Collin P. Auwarter, Professor and Research Specialist, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105

Field research was conducted at the Northern Plains Potato Grower's Association Irrigation Research site near Inkster, ND to determine if increasing the glyphosate droplet concentration by reducing the water volume would increase injury to potato and whether this increase in injury be similar at all growth stages. This was accomplished by comparing plant and tuber injury from glyphosate applied at 20, 5, or 1 GPA to 'Russet Burbank' plants at the tuber initiation (TI), early bulking (EB), and late bulking stages (LB).

The potato variety 'Russet Burbank' was planted on May 24 using a Harrison double-row planter with 12-inch spacing between seed pieces and 36 inches between rows. Glyphosate was applied at one-sixth, and one-twelfth the standard use rate (0.125 and 0.0625 lb ai/A) with a CO_2-pressurized ATV sprayer equipped with HB/HC #2 and #5 nozzles with a spray volume of 20 GPA (70 psi and 1.8 mph), 5 GPA (25 psi and 3.6 mph), or 1 GPA (25 psi and 7.2 mph). AMS was included to the spray solution and reduced accordingly. The field design was a randomized complete block, factorial arrangement, with four replicates. Maintenance programs were conducted throughout the growing season to apply fungicides and insecticides. Plants were harvested September 25 with a single-row Hasia harvester and then graded at Fargo.

Visual injury symptoms from glyphosate applications were subtle (chlorosis at growing points) regardless of glyphosate rate or application timing. Plants treated with glyphosate recovered quicker and showed less injury symptoms than previous years due to better environmental conditions in 2009. Plants treated with 0.13 lb/A glyphosate at the TI stage when applied at 20 GPA or at the EB stage when applied at 5 GPA had significant marketable and total yield loss from the reduction in tuber size. Plants treated with glyphosate produced similar number of tubers in comparison to the untreated except when plants were treated with 0.06 lb/A glyphosate applied at 20 GPA at the TI stage, which had significantly more tubers. Additional tuber loss would have occurred if tubers were to be sold for fresh market due to growth cracks and elephant hide skin in many of the tubers when plants were treated with glyphosate at the TI or EB stage.

SEASON-LONG WEED CONTROL IN TREE FRUIT WITH PREEMERGENCE AND POSTEMERGENCE HERBICIDES. Rodney V. Tocco*, Bernard H. Zandstra, and Chad M. Herrmann, Research Assistant, Professor, and Graduate Research Assistant, Department of Horticulture, Michigan State University, East Lansing MI 48824-1325.

Tree fruit growers have used PSII inhibitors for residual weed control for many years. Simazine, diuron, and terbacil still are used widely because of their effectiveness and low cost. However, lack of rotation of mode of action has led to weed resistance and species shifts. Most orchards are treated at some time during the year with glyphosate to kill emerged weeds. The very narrow range of herbicides used is a result of lack of good alternatives, low cost, and grower habit. Several new herbicides have been registered or are being developed for pre or post-emergence weed control in perennial crops. Experiments were conducted in 2008 and 2009 to compare weed control efficacy and potential crop injury on dwarf apples at Clarksville and East Lansing, MI. Preemergence treatments were applied in fall or early spring (Early Pre-EPRE) or late spring (Late Pre-LPRE). Postemergence treatments were applied in early June (Early Post-EPOS) or early July (Late Post-LPOS).

Flumioxazin applied in fall at 0.383 lb/a plus glyphosate 0.43 lb/a provided essentially 100% control of all weeds until June 1, after which horseweed, white clover, wild carrot, birdsfoot trefoil, and perennial ryegrass emerged. The same treatments applied in early-May (LPRE) maintained slightly better control of horseweed, white clover and perennial ryegrass through August 1, after which all three weeds proliferated. Good control of other grasses and broadleaves was maintained until September. Saflufenacil applied at 0.045 lb/a in mid-April (EPRE) did not control grasses. It gave good control of most broadleaves including horseweed until August 1. It was weak on curly dock, dandelion, shepherd's purse and other mustards. The same treatments applied in early-May (LPRE) maintained better control until June 1, after which alfalfa, birdsfoot trefoil, and wild carrot proliferated. Rimsulfuron applied at 0.064 lb/a EPRE suppressed most broadleaves until early June, when prostrate knotweed, alfalfa, curly dock, birdsfoot trefoil and redstem filare began to emerge. The same treatments applied in early-May (LPRE) and seperately in early-June (EPOS) maintained slightly better control through September 1. Sulfentrazone applied at 0.375 lb/a EPRE did not control grasses, red clover, and birdsfoot trefoil. It was weak on alfalfa, dandelion, horseweed, rough fleabane and shepherd's purse. It controlled common chickweed, prostrate knotweed, and common lambsquarters. Mesotrione applied at 0.188 lb/a EPRE did not control grasses, but suppressed all broadleaves through June 1. Terbacil applied at 2.4 lb/a EPRE controlled all weeds through July 1. Application of glyphosate at 0.43 lb/a or glufosinate at 1.04 lb/a in early June (EPOS) following various EPRE treatments extended control of all weeds except perennial ryegrass into September.

None of the treatments caused visual injury to apple. If residual herbicides are rotated and applied with foliar-active herbicides to kill emerged vegetation, it is possible to maintain season-long weed control and avoid species shift or weed resistance.

INTRODUCTION OF INDAZIFLAM FOR WEED CONTROL IN FRUIT, NUT, AND GRAPE CROPS. Mark D. Parrish, R. Darren Unland, and William J. Bertges, Director of Herbicide Development, Product Development Manager, and Senior Scientist, Bayer CropScience, Research Triangle Park, NC 27709. (164)

Indaziflam is a new cellulose biosynthesis inhibitor under development by Bayer CropScience for broadspectrum weed control in perennial fruit, nut, and grape crops. This new active ingredient will be formulated as a suspension concentrate and marketed as Alion® for control of monocot and dicot weeds when applied alone or in a tankmix with other herbicides. Pending approval by EPA, Alion® will provide residual preemergence weed control for several months with excellent crop safety. The Alion® formulation readily mixes with postemergence herbicides to add residual control to burndown products such as glufosinate. Over 500 field trials have been conducted throughout the US since 2003 and have demonstrated that 73 – 95 g ai ha-1 indaziflam will provide 80% or greater control of key weeds 90 days or longer after treatment. Length of control has been equal to or longer than all other registered products tested at the manufacturer's recommended use rates. Indaziflam will be an effective tool to manage weed populations that are resistant to other modes of action including EPSP synthase inhibitors, ALS inhibitors, and PSII inhibitors. Indaziflam and Alion® have very favorable toxicological properties with no evidence of effects on immunotoxicity, developmental toxicity, reproductive toxicity, genotoxicity or carcinogenicity. Based on residue tests results, Bayer CropScience anticipates a 14 day or less preharvest interval for all crops and no commodity trade restrictions.

BENCHMARK STUDY: VARIATION IN WEED MANAGEMENT TACTICS IMPLEMENTED IN GLYPHOSATE-RESISTANT CROPPING SYSTEMS. Bryan G. Young, Joseph L. Matthews, David L. Jordan, Micheal D. K. Owen, David R. Shaw, Stephen C. Weller, Robert G. Wilson, William G. Johnson, and Philip M. Dixon, Professor and Researcher, Southern Illinois University, Carbondale, IL 62901, Professor, North Carolina State University, Raleigh, NC 27695, Professor, Iowa State University, Ames, IA 50011, Professor, Mississippi State University, Mississippi State, MS 39762, Professor, Purdue University, West Lafayette, IN 47907, Professor, University of Nebraska, Scottsbluff, NE 69361, Professor, Purdue University, West Lafayette, IN 47907, Professor, Iowa State University, Ames, IA 50011.

During 2006 and 2007 a total of 155 commercial fields in Illinois, Indiana, Iowa, Nebraska, North Carolina, and Mississippi were the foundation for comparing weed management tactics implemented by growers versus management practices recommended by a state university weed specialist. The recommendations provided by the university specialist were targeted at deterring the selection of glyphosate-resistant weed species. Each field was divided into two sections with half managed as typical for the grower and the other half managed following university recommendations. Fields were categorized into three cropping systems: 1) a single continuous glyphosate-resistant (GR) crop, 2) a rotation of two GR crops, and 3) a GR crop rotated with a non-GR crop.

Over both grower and university sections, the frequency of glyphosate applications used for weed management was greatest in a single continuous GR crop (2 applications/year) followed by a rotation of two GR crops (1.6 applications/year) and least with a GR crop rotated with a non-GR crop (1 application/year). In most instances, the university recommendation did not reduce the frequency of glyphosate applications compared with grower practices. However, growers used 3 applications of glyphosate on an annual basis in GR cotton compared with an average of 2 and 1.2 applications, respectively, for GR soybean and corn. The rate of glyphosate used per application was similar between grower and university (~ 840 g ae/ha). The application rate of glyphosate increased from 763 to 913 g/ha, respectively, as the cropping system moved from a GR crop rotated with a non-GR crop to a continuous monoculture of a GR crop. Averaged over all crops and fields, growers used glyphosate as the only herbicide for weed management in 40% of the sites compared with only 3% for the university recommendation. Instead of excluding glyphosate as a weed management tool, the university recommendation utilized soil residual herbicides or tank-mixtures with glyphosate twice as frequently as growers. At 68% of the sites, university weed scientists recommended using a preplant residual herbicide in addition to glyphosate.

BENCHMARK STUDY: IMPACT OF GLYPHOSATE-RESISTANT CROPS ON WEED POPULATION DENSITY. Stephen C. Weller, Micheal D.K. Owen, Bryan G. Young, David R. Shaw, Robert G. Wilson, David L. Jordan, and Philip Dixon, Professor, Purdue University, West Lafayette, IN 47907, Professor, Iowa State University, Ames, IA 50011, Professor, Southern Illinois University, Carbondale, IL 62901, Professor, Mississippi State University, Mississippi State, MS 39762, Professor, University of Nebraska, Scottsbluff, NE 69361, Professor, North Carolina State University, Raleigh, NC 27695 and Professor, Professor, Iowa State University, Ames, IA 50011.

A multi-state, four-year field scale study was initiated in 2006 to assess the impact of weed management tactics on weed populations in glyphosate-resistant (GR) crops. A total of 155 commercial fields in Illinois, Indiana, Iowa, Mississippi, Nebraska and North Carolina were included in the study and seedbank, weed populations and yields were enumerated during the growing season. Fields selected for the project in 2006 had been in a glyphosate-resistant cropping system for the previous 3 yr. Each field was divided into two sections with half managed for weed control as typical for the grower and the other half managed following recommendations by a university weed specialist within the state. Forty sample locations were established throughout each field with GPS coordinates within the two sides of the study site. Cropping systems examined in the study included; continuous GR crop (corn, soybean, and cotton), a rotation of two GR crops and a rotation of a GR crop and a non-GR crop. Weed density was measured in the spring prior to crop planting, after crop emergence, two weeks after the last postemergent herbicide application and at crop harvest in both years. Weed counts by species were taken in a 0.5 M^2 area in the 20 GPS locations in each half of the field. Weed density was compared among the various cropping systems and between the grower and university sides of the field. In 2006, prior to crop planting, fields in continuous cotton had greater weed density than all other cropping systems. The measurements after crop emergence showed that continuous GR corn had greater weed density than continuous cotton. Interestingly, this higher weed density was reduced in fields where GR corn was rotated with a different GR crop or with a non-GR crop. At harvest, weed density was similar in fields cropped continuously with GR corn, cotton or soybeans but in fields practicing rotation, weed density was reduced compared to continuous GR soybean or GR corn. In 2007 the weed density measurements followed a similar pattern as in 2006 with the highest weed densities occurring in fields where a GR crop was grown continuously with no rotation. For example, at crop planting, weed density was higher in continuous GR soybean and cotton than in continuous GR corn but when the GR soybeans were rotated with a different GR crop or with a non GR crop weed density was lower. Weed density after the last postemergent herbicide application was highest in continuous corn compared to continuous soybean or cotton but densities were reduced when rotation with another crop was practiced. This pattern of weed densities continued at harvest in the various cropping systems. In comparisons of weed densities in grower versus university sides of the fields in both 2006 and 2007, there was a trend towards reduced weed density on the university side. Although, only in a few cases were these differences significant. This trend was most likely due to including a soil applied preemergence herbicide with glyphosate on the university side versus growers relying solely on glyphosate. These results suggest that both cropping system and weed control programs play a critical role in the density of weeds in glyphosate resistant crops.