INDUSTRY DONATIONS OF INTELLECTUAL PROPERTY RIGHTS TO UNIVERSITIES. Thomas S. Woods, Director, Intellectual Assets Management, DuPont Intellectual Assets Business, E. I. du Pont de Nemours and Company, Wilmington, DE 19880-0708.

Scientists involved in industrial research and development programs typically make many more discoveries than their companies can utilize commercially. Accordingly, many valuable technologies remain lost in company reports or locked into unused patents, never to provide any value to the company or to society at large. In the early 1990's, several companies became interested in the idea of donation of these unutilized intellectual assets to non-profit institutions, primarily universities or associated organizations. Within the donee institutions, the donated embryonic technologies could provide the nucleus for elaborated research programs, and in some cases, could provide eventual financial benefit to the donee institutions by licensing or sale of the enriched technologies to interested commercial entities. In the last few years, many companies have now begun to engage in this practice, with the result that a multitude of otherwise hidden technologies have been brought into public view, and productive scientific dialog has been opened between industrial scientists and their counterparts in academia. Both donor and donee organizations have been extremely pleased with the process and its resultant benefits. This lecture will explore the general issues and considerations associated with donation of intellectual assets and will describe one approach to the process as it is currently practiced.

COMMERCIALIZATION OF INTELLECTUAL PROPERTY RIGHTS BY UNIVERSITIES. Bob Reader, Director, Acquired Technologies, Mid-America Commercialization Corporation, 1500 Hayes Drive, Manhattan, KS 66502.

Technology commercialization is a high-growth field where lawyers, scientists and entrepreneurs come together to build high-growth businesses. Much of our nation's wealth stems from the commercialization of new technologies, with many of these new technologies being created at or somehow enhanced by university research. Due to the recently adopted practice by industry of intellectual property donation, technologies now flow both from and to universities. This discussion will consider the impact of IP donations to the universities, and the role of technology commercialization for both university-created and industry-donated intellectual property rights. The discussion of technology commercialization will include both the traditional licensing model as well as the increasingly popular model of technology startup companies.

DIFFERENTIAL GRAIN SORGHUM RESPONSE TO TANK MIXES OF METSULFURON + 2,4-D.
Dave W. Brown, Kassim Al-Khatib, and David L. Regehr, Graduate Research Assistant, Associate Professor, and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506

Field experiments to study differential sorghum hybrid responses to metsulfuron + 2,4-D were conducted in 2000 and 2001 at Ashland Bottoms research farm near Manhattan, Kansas. Sorghum hybrids were selected to represent a broad range of genetic diversity, and to encompass popular sorghum hybrids among producers in the Midwest. In general, metsulfuron + 2,4-D caused visible injury to all hybrids at 1 and 2 weeks after treatment (WAT). However, plants recovered from symptoms, and some hybrids appeared normal at the end of the growing season. Differential hybrid responses to metsulfuron + 2,4-D application were observed at 1 and 2 WAT in 2000, and 4 WAT in 2001. In addition, plant heights of Garst 5440, Garst 5515, and Mycogen 1506 were reduced by application of metsulfuron + 2,4-D in both 2000 and 2001. Furthermore, there was a differential delay in flowering data in 2000. In 2001 metsulfuron +2,4-D delayed flowering by as much as three days, averaged over all hybrids, but there was no differential hybrid response. Overall, this study shows a differential hybrid response to metsulfuron + 2,4-D

INHERITANCE OF ISOXAFLUTOLE TOLERANCE IN CORN. Aaron S. Franssen*, David S. Douches, and James J. Kells, Graduate Research Assistant, Professor, and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Isoxaflutole (IFT), and its primary metabolite diketonitrile (DKN), are effective inhibitors of 4-hydroxyphenylpyruvate deoxygenase (HPPD), an enzyme involved in the plastoquinone biosynthetic pathway. Tolerance to IFT is typically attributed to the rapid metabolism of IFT and DKN into an inactive benzoic acid metabolite. Sensitive species exhibit the traditional bleaching associated with this mode of action.

Two inbred lines from different corn families were selected for their known response to IFT in order to determine the number of genes that influence IFT tolerance. Inbred 18 is from the B73 family and inbred 30 is from the C103 family. Inbred 18 was characterized as being sensitive (S) whereas inbred 30 was tolerant (T). Hybrid (F_1) crosses made were 18x30 (SxT) and a reciprocal 30x18 (TxS). Second generation (F_2) hybrids for 18x30 were created by self-pollinating the F_1 hybrids the following season.

Greenhouse trials were conducted to screen the inbreds, F_1 hybrids, and F_2 hybrids for tolerance to IFT. Corn inbreds and hybrids were screened with 157 g ai ha^{-1} of soil incorporated IFT. A visual rating for percent bleaching was determined for each individual plant on a scale of 0-100, two weeks after treatment.

Understanding the inheritance of IFT tolerance will help breeders in producing hybrids that will be less likely to respond adversely to IFT. Tolerance to IFT also has the potential to be used as an easily scored phenotypic marker, which could be used in corn mapping projects.

VOLUNTEER CORN CONTROL IN IMIDAZOLINONE-TOLERANT CORN WITH IMAZETHAPYR PLUS IMAZAPYR. David H. Johnson, E. Jamie Retzinger, Gary M. Fellows, and Tom J. Hartberg. BASF Corp., St. Paul, MN.

Volunteer glyphosate-resistant corn control with imazethapyr plus imazapyr was evaluated in imidazolinone-tolerant corn in 2000 and 2001 in Minnesota, Iowa, and Wisconsin. Pieces of cobs collected the previous fall from fields of glyphosate-tolerant corn were planted into plots of imidazolinone-tolerant corn and treated when the volunteer corn was 4 to 6 inches tall. Treatments were an untreated check, imazethapyr plus imazapyr at 0.056 lb/a with 0.25% v/v NIS and 1 qt/a 28-0-0, and imazethapyr plus imazapyr at 0.056 lb/a with 1.0% v/v MSO and 1 qt/a 28-0-0. Volunteer corn control, pollen shed, silking, and grain production were evaluated to determine if the herbicides could prevent contamination of nearby corn crops with pollen bearing unwanted genetically modified traits. Imazethapyr plus imazapyr gave 60 to 95% volunteer corn control, with MSO giving better control than NIS. Lack of complete control is probably because many plants in the clumps did not receive a full dose of herbicides. In untreated plots, 10 to 63% of the volunteer corn plants silked or shed pollen. In MN and IA, none of the treated volunteer corn plants produced silks or grain. Less than 2% of the plants shed pollen and none produced grain when NIS was used. No volunteer corn plants shed pollen when MSO was used. In WI, less than 12% of the volunteer corn plants silked or shed pollen, and less than 2 bu/a of grain was harvested from treated volunteer corn plants. At all locations pollen shed occurred several days after the hybrid corn was pollinating. Imazethapyr plus imazapyr eliminated or greatly reduced pollen shed, silking, and grain production from volunteer glyphosate-tolerant corn plants growing in imidazolinone-tolerant corn. These results show that imazethapyr plus imazapyr applied to imidazolinone-tolerant corn effectively controls volunteer corn and prevents or greatly reduces harvested grain contamination or cross contamination of hybrid corn with pollen bearing unwanted genetically modified traits.

KOCHIA CONTROL IN GRAIN SORGHUM WITH FLUROXYPYR-BASED TREATMENTS. Mark D. Lubbers, Phillip W. Stahlman, and Kassim Al-Khatib, Graduate Research Assistant, Professor, and Associate Professor, Kansas State University Agricultural Research Center, Hays, KS 67601, and Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Postemergence herbicides currently registered for use in grain sorghum have narrow margins of crop safety, lack flexibility in application timing, or do not effectively control some important weeds, such as kochia, in grain sorghum. Fluroxypyr effectively controls kochia in cereal grain crops and has promising potential for use in grain sorghum. Field experiments were conducted at the Kansas State University Agricultural Research Center, at Hays, KS to evaluate the effects of fluroxypyr rates, application timings, and tank mixtures on grain sorghum tolerance and kochia control, and to evaluate the effect of adjuvants on fluroxypyr efficacy. In both experiments, kochia was overseeded and a preemergence treatment of *S*-metolachlor was applied at 660 g ai ha^{-1} to control grass weeds. Fluroxypyr + atrazine + crop oil concentrate (COC) at rates of 210 g ae ha^{-1} + 560 g ai ha^{-1} + 1% v/v and fluroxypyr + metsulfuron + non-ionic surfactant (NIS) at rates of 210 g ha^{-1} + 2.1 g ai ha^{-1} + 0.5% v/v provided the greatest kochia control at both timings of application, when sorghum was 10 to 15 cm and 20 to 25 cm tall and kochia was 3 to 12 cm and up to 20 cm tall, respectively. However, fluroxypyr + metsulfuron + NIS injured grain sorghum at both times of application and reduced sorghum yield when applied at the later timing. Fluroxypyr at 210 g ha^{-1} plus NIS provided less kochia control than fluroxypyr mixed with atrazine and metsulfuron, but provided better control compared to the commercial standard of dicamba + atrazine. Of seven adjuvants tested, none improved control of kochia by fluroxypyr applied at 105 g ha^{-1} and two non-ionic surfactants (Liberate and Dispatch 111) decreased control.

COMPARISON OF PREEMERGENCE AND POSTEMERGENCE HERBICIDES FOR CONTROL OF COMMON WATERHEMP IN CORN. Hank J. Mager, Bryan G. Young, and Ronald F. Krausz, Undergraduate Student, Assistant Professor, and Researcher, Department of Plant, Soil and General Agriculture, Southern Illinois University, Carbondale, IL 62901.

Two field studies were conducted in 2000 and 2001 to evaluate the effectiveness of preemergence and postemergence herbicides for control of common waterhemp in corn. In the preemergence study, herbicide treatments included atrazine, simazine, RPA 201772 and ZA 1296 applied at ½ and 1X the labeled use rates. Herbicides evaluated in the postemergence study included the following: carfentrazone, atrazine, bromoxynil, flumiclorac, 2,4-D, dicamba, dicamba & diflufenzopyr, nicosulfuron & rimsulfuron & atrazine, primisulfuron & dicamba, dicamba & diflufenzopyr & nicosulfuron, primisulfuron & prosulfuron, flumetsulam & clopyralid, glyphosate, and ZA 1296. Dicamba, dicamba & diflufenzopyr, and 2,4-D were each applied at three different rates and all other herbicides were applied at a single rate. Postemergence herbicides were applied when common waterhemp was 10 cm in height.

In the preemergence study, common waterhemp control 56 DAP in 2000 was at least 88% from atrazine, ZA 1296, and the 1X rates of simazine and RPA 201772. However in 2001, no herbicide treatment controlled greater than 88% of common waterhemp at 56 DAP. Common waterhemp control was 82 to 88% from atrazine and the 1X rates of simazine, ZA 1296, and RPA 201772 in 2001. Increasing the herbicide rate from ½ to 1X increased common waterhemp control with simazine and RPA 201772 in 2000 and with simazine, RPA 201772, and ZA 1296 in 2001. Preemergence control of common waterhemp was more consistent with 1/2X rates of atrazine compared to the other herbicides at 1/2X rates. Common waterhemp control was similar from all herbicides at the 1X rate in both years. All herbicide treated plots yielded similar to handweeded plots in both years.

In the postemergence study, applications of glyphosate, ZA 1296, dicamba & diflufenzopyr & nicosulfuron, and the high rates of 2,4-D, dicamba, and dicamba & diflufenzopyr controlled common waterhemp at least 88% at 28 DAT in both years. Common waterhemp control 28 DAT was 80 to 85% from carfentrazone, atrazine and bromoxynil in 2000 but only 0 to 77% in 2001. Similarly, nicosulfuron & rimsulfuron & atrazine and primisulfuron & dicamba controlled 80 to 83% of common waterhemp in 2000 and 58 to 67% in 2001. Higher air temperatures at the time of herbicide application in 2000 may have contributed to the increased common waterhemp control observed with some herbicides that year. Common waterhemp control was greatest with treatments that included growth regulator herbicides, glyphosate or ZA 1296. Flumetsulam & clopyralid and primisulfuron & prosulfuron provided no control of common waterhemp in either year. In general, corn yield was similar in all herbicide treated plots with the exception of flumetsulam & clopyralid and primisulfuron & prosulfuron treated plots which yielded similar to the nontreated plots.

EFFICACY OF MESOTRIONE IN KANSAS. Patrick W. Geier, Phillip W. Stahlman, Larry D. Maddux, David L. Regehr, and Curtis R. Thompson, Assistant Scientist and Professor, Kansas State University Agricultural Research Center, Hays, KS 67601, Professor, Department of Agronomy, Kansas State University, Topeka, KS, 66618, Professor, Department of Agronomy, Kansas State University, Manhattan, KS, 66506, and Associate Professor, Kansas State University Southwest Research and Extension Center, Garden City, KS 67846.

Experiments were conducted near Hays, Manhattan, Topeka, and Tribune, KS in 2001 to evaluate the effects of application timing and tank mixtures on ZA 1296 (proposed name mesotrione) efficacy in corn. Data were analyzed by location because of differences in weed spectrums, herbicide rates, and location interactions for corn yield. Weed species controlled 93% or more regardless of herbicide treatment included redroot pigweed, tumble pigweed, witchgrass, stinkgrass (Tribune), Palmer amaranth (Manhattan), and large crabgrass (Manhattan and Topeka). Mesotrione, applied PRE at 0.18 lb/A with metolachlor or metolachlor&atrazine, or applied POST at 0.09 lb/A with or without atrazine following metolachlor or metolachlor&atrazine PRE controlled kochia, Russian thistle (Tribune), and Palmer amaranth (Topeka) by 92% or more. At Hays, puncturevine and green foxtail control was less than 92% when mesotrione in combination with metolachlor and/or atrazine was applied PRE, and no treatment provided as much as 85% longspine sandbur control. Volunteer sunflower was controlled 90% or more only when dicamba&atrazine followed dimethenamid or when primisulfuron&prosulfuron followed metolachlor. However, all treatments except metolachlor followed by mesotrione controlled common sunflower 90% or more at Topeka. Only metolachlor followed by primisulfuron&prosulfuron controlled Rox orange (simulating shattercane) at Manhattan. Velvetleaf control was greater than 85% with each treatment except metolachlor plus mesotrione or metolachlor&atrazine PRE at Manhattan. At the same location, metolachlor&atrazine with or without mesotrione PRE, metolachlor&atrazine followed by mesotrione, and dimethenamid followed by dicamba&atrazine controlled ivyleaf morningglory 90% or more. Corn yields at Manhattan and Hays generally were highest when corn received mesotrione alone or in combination with atrazine POST, or when dicamba&atrazine or primisulfuron&prosulfuron were applied POST. At Topeka, yields were generally highest when mesotrione was applied PRE with metolachlor or metolachlor&atrazine or when mesotrione alone was applied POST. Corn yields at Tribune were not determined due to drought.

EVALUATION OF CARFENTRAZONE APPLIED ALONE AND IN TANK MIXTURE IN GRAIN SORGHUM. Anthony D. White, Patrick W. Geier, Phillip W. Stahlman, Troy M. Price, and David L. Regehr, Department of Agronomy, Kansas State University, Hays, Colby, and Manhattan, KS.

Carfentrazone ethyl is a protoporphyrinogen oxidase (PPO) inhibitor herbicide registered for broadleaf weed control in various crops, including grain sorghum. Carfentrazone provides a weed control alternative to atrazine at a lower cost per acre and has no rotation restrictions to subsequent field crops grown in Kansas. Studies were conducted in Colby, Hays, and Manhattan, KS (two trials at each location) to evaluate the effects of carfentrazone alone or in a tank mixture with atrazine, 2,4-D (amine), fluroxypyr, prosulfuron, dicamba, metsulfuron, or halosulfuron in grain sorghum. *S*-metolachlor was applied to one of the trials at each location to provide grass control. Not all weeds were present at each location and are indicated accordingly. Carfentrazone by itself provided greater than 97 % control of redroot pigweed (Colby and Hays), tumble pigweed (Colby), kochia (Colby), and puncturevine (Hays) at 17 DAT. These species were also controlled (>97%) when carfentrazone was used in combination with the herbicides previously listed. Palmer amaranth (Manhattan) control was inconsistent between trials for carfentrazone applied alone or in combination with atrazine, 2,4-D, dicamba, halosulfuron, metsulfuron, or prosulfuron. Velvetleaf control was significantly higher in carfentrazone tank mix treatments compared to carfentrazone alone. Treatments containing carfentrazone caused significant leaf necrosis at Colby and Hays 1 DAT. However, a rating taken at 19 DAT indicated that leaf necrosis was undetectable with the emergence of new leaves. Trials in Manhattan showed minimal plant injury 7 DAT. Corn exhibited no visible injury at any location prior to harvest.

EFFICACY WITH DRIFT REDUCING NOZZLES AND ADDITIVES. Adam K. Johnson, Robert N. Klein, Alex R. Martin and Fred W. Roeth, Graduate Research Assistant, Professor, Professor and Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE 68583-0915.

Field studies were conducted twice in both 2000 and 2001 to evaluate efficacy with drift reducing nozzles and drift reducing additives. Twelve treatments were evaluated in 2000 and fifteen in 2001. The standard treatment was the XR TeeJet nozzle at 276 Kpa. Additional nozzles tested were other flat fan nozzles, air induction types, flood style nozzles, the Turbo TeeJet and Turbo Drop nozzle. Three additives (Array, Border and Placement) were tested with the XR TeeJet and AI TeeJet nozzles.

Plots were 4.6m x 9.1m long and were split into three rows of sorghum and three rows of non-herbicide tolerant soybeans (0.76m spacing). The middle four rows of each plot were treated. All the treatments were applied with glyphosate (1.2 L/ha) and with glufosinate (1.5 L/ha). Treatments were applied with a 3m tractor mounted boom equipped with four nozzles on 0.76m spacing. Tractor speed was 12.9 km/hr and boom height was 0.6m for all nozzles except flood style nozzles carried 0.5m above the crop canopy. One to two weeks after treatment, plots were rated for % crop injury.

Drift reducing nozzles such as the Turbo FloodJet, Turbo TeeJet, Turbo Drop and AI TeeJet all provided good efficacy. Drift retardants did not significantly influence herbicide efficacy when used in conjunction with flat fan nozzles. In some cases drift-reducing additives used with a venturi style nozzle reduced weed control as measured by % crop injury. Drift reducing nozzles are a one-time purchase, while additives need to be added to the tank with each fill. Drift management decisions should always involve proper nozzle selection.

INFLUENCE OF DRIFT REDUCING NOZZLES WITH GLYPHOSATE AND FOMESAFEN ON COMMON WATERHEMP CONTROL. Jeffrey A. Bunting and Christy L. Sprague, Graduate Research Assistant and Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

With the increase of transgenic crops over the past three years, new technologies in nozzle performance have been developed with the sole objective of reducing off target movement of non-selective herbicides. Previous weed control studies have addressed herbicide efficacy with standard flat fan nozzles (TeeJet XR). However, there is little information on herbicide efficacy using the new drift reducing nozzles that are currently available. This study was conducted to determine the differences of three commonly used drift reducing nozzles, DG TeeJet drift guard spray tips, DG80015 and DG8003; AI TeeJet air induction spray tips, AI110015VS and AI110025VS; and Turbo TeeJet wide angle flat spray tips, TT11001-VP and TT11002VP compared with the standard XR TeeJet extended range flat spray tips, XR11001VS and XR11002VS. Each nozzle was assessed at two outputs, 94 and 187 L/ha. Water sensitive paper was placed in each of the treatments to assess spray coverage. Common waterhemp (*Amaranthus rudis*) was the target species and herbicide applications were made when the waterhemp was between 10 and 20 cm. Two herbicides, glyphosate (a systemic herbicide) and fomesafen (a contact herbicide), were examined in this study. Glyphosate at 0.83 kg a.e./ha and fomesafen at 0.40 kg a.i./ha were applied on June 30 in 2000 and July 28 in 2001. Observations were made at 14 and 28 days after treatment (DAT) to assess weed control and re-growth of the target species. Across both spray volumes, glyphosate applied with the drift guard, Turbo TeeJet, and extended range nozzles provided greater than 90% common waterhemp control, 14 DAT. Glyphosate provided less than acceptable control of common waterhemp when applied at 187 L/ha through the air induction nozzles. Control of common waterhemp was more variable with the different nozzles when fomesafen was applied. Across both spray volumes, common waterhemp control was significantly lower with the air induction nozzles compared with the other nozzles. At the lower spray volume, common waterhemp control was significantly greater when fomesafen was applied through the Turbo TeeJet nozzles. However, this control was only 70%, 14 DAT. Common waterhemp control ranged between 72 and 82% with the drift guard, Turbo Teejet, and extended range nozzles at 187 L/ha. Overall, nozzle selection and spray volume had a greater impact on common waterhemp control when using a contact herbicide, such as fomesafen.

GLYCINE MAX AND WEED DIFFERENTIATION USING REMOTE SENSING TECHNIQUES.
Loree B. Johnston, Kevin D. Gibson and Case R. Medlin, Graduate Research Assistant, Assistant Professor of Weed Science and Extension Weed Specialist, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907-1155; Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK 74078-6028.

Experiments were conducted at the Agronomy Research Center (ARC) near West Lafayette, IN and the Davis-Purdue Agricultural Research Center (DPAC) near Farmland, IN to evaluate the accuracy of remote sensing technology for detecting species-specific weed infestations. Velvetleaf, giant ragweed, common lambsquarters, giant foxtail and weed-free plots (6-m by 6-m) were established with and without drilled soybeans in May of 2001. Ground-based reflectance measurements were collected approximately ten weeks after planting with a GER (Geophysical and Environmental Research) 2600 at ARC and a GER 1500 at DPAC. Three readings per plot were collected at ARC and five readings per plot at DPAC. Both readings were taken near solar noon and with <5% cloud cover.

Discriminate analysis techniques were used to develop models based on up to twelve bands of reflectance that identified weed species and calculated the accuracy of classifications. Models formed to differentiate individual weed species in monocultures were nearly 100% accurate at correctly identifying species on a site-specific basis. However, when the models were applied to the opposite location, species classification accuracies dropped to 0%. Models were also formed for classifying individual weed species interseeded with soybeans. These models were nearly 100% accurate on a site-specific basis, however, the classification accuracy dropped to near 0% when the model was applied to the opposing location. A third set of models was developed to detect weed infestations or absence of weeds in the soybean crop. Models formed for differentiating between weedy versus weed-free plots were at least 80% on a site-specific basis. When these models were applied to the opposing locations accuracies were 75-80% accurate in differentiating between weedy and weed-free soybeans.

This research suggests there is substantial potential for classifying weed species with remote sensing, however additional work on the factors that contribute to variation in individual species reflectance patterns must be addressed before this potential can be realized.

GLYPHOSATE EFFICACY AS AFFECTED BY MIXING SEQUENCE WITH ADJUVANTS.
Edward Szelezniak, Zenon Woznica, and John D. Nalewaja, Visiting Scientist, Visiting Scientist, and Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Ammonium sulfate (AMS) is used to enhance glyphosate action and to overcome antagonistism of glyphosate by spray carrier salts. Many AMS labels indicate that the product should be added to the spray water before the glyphosate. This recommendation is based on the assumption that glyphosate combines with minerals in solution and that ammonia ions from ammonium sulfate compete with the minerals to form complexes with glyphosate. However, it has been shown that sulfate ions function to remove calcium during spray droplet drying because calcium sulfate has lower solubility than glyphosate-calcium salt. Experiments were conducted using various AMS formulation adjuvants and water conditioning agents added before or after glyphosate in waters with various salt concentrations. Glyphosate at 100 g ae/ha was applied to wheat in the greenhouse using 80 L/ha. Glyphosate at 55 g ae/ha was applied to wheat, oat, and rye bioassay species in the field also using 80 L/ha. Field data were averaged over species, two rating dates, and four replicates. The spray carriers contained cations (mg/L) as follow: Fargo tap with calcium 30, magnesium 8, sodium 59, calcium carbonate hardness 108; Paulson well with calcium 240, magnesium 293, sodium 173, calcium carbonate hardness 1806; and Browerville well with calcium 102, magnesium 28, sodium 5, calcium carbonate hardness 369. Iron also was present in Browerville water at 9 mg/L but was at less than 1 mg/L in the other waters.

Field results indicated that addition of AMS or citric acid at 1% (w/v) plus nonionic surfactant Activator 90 at 0.5% (v/v), Surfate™ at 1 or 2% (v/v) or Class Act® Next Generation at 2.5% (v/v) before or after the glyphosate to the spray mixture did not influence glyphosate efficacy with any of the water carriers. The water conditioning agent Choice™ at 0.75% (v/v) plus nonionic surfactant Activator 90 at 0.5% (v/v) resulted in 12% enhancement (LSD=9) of glyphosate efficacy when added to the Browerville water before glyphosate. This was the only water high in iron. Choice™, which is a blend of salts of polyacrylic, hydroxy carboxilic, propionic acid, phosphate ester and ammonium sulfate, may be effective for iron deactivation. However, Choice™ plus nonionic surfactant Activator 90 still were significantly less effective than the other adjuvants both in this high-iron water and the other waters. The two formulated AMS products, Surfate™ and Class Act® Next Generation, were or tended to be more effective for enhancing glyphosate efficacy than AMS at 1% (w/v) plus nonionic surfactant Activator 90 at 0.5% (v/v).

Greenhouse results supported the field results and further indicated that AMS was equally effective whether added before or after glyphosate regardless of calcium chloride concentration (0 to 500 mg Ca^{2+}/L) or if AMS was mixed immediately, 3, 12, or 24 h before or after glyphosate was added to the spray mixture. These results clearly indicate that AMS is equally as effective with glyphosate when added the spray mixture before or after glyphosate and supports the assumption that the glyphosate/spray carrier cation complex forms during droplet drying.

REFLECTANCE RESPONSE PATTERNS OF CORN AS AFFECTED BY HERBICIDE APPLICATIONS. Wesley J. Everman, Thomas T. Bauman, and Case R. Medlin, Graduate Research Assistant, Professor of Weed Science, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907-1155; Assistant Professor of Weed Science, Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK 74078-6028

The use of remote sensing in weed science has led to increased research efforts to map weed populations and the dynamics of those populations that impact the spectral reflectance properties of the crop canopy. It may be possible to find reflectance response patterns of individual species that would open the future to a broad expanse of possibilities in the field of remote sensing and site-specific weed management. To assist the research being conducted in this area, the impacts of POST applied herbicides on the crop reflectance response patterns are being researched. The identification of herbicides that do not impact the spectral response pattern of the crop could be used for weed control over a large experiment area, with weeds of interest being established in untreated areas. This would reduce hand-weeding needed to maintain species compositions. Experiments were conducted at the Agronomy Research Center near West Lafayette, IN and the Davis-Purdue Agricultural Center near Farmland, IN. POST corn herbicides evaluated were nicosulfuron, atrazine, dicamba + diflufenzopyr, primisulfuron, 2,4-D, and bromoxynil. Treatments were selected for their range of symptomology as well as their common usage across the Midwestern Corn Belt. Multispectral aerial images composed of three bands of reflectance were collected over the test areas from 6 to 11 weeks after planting from two sources, with ranges: band 1: 80 nm, band 2: 70 nm, and band 3: 30 nm. Ground-based reflectance data were also collected with a GER 2600 field spectrometer mounted 7m above the crop canopy 6 weeks after planting. Five readings per plot were collected near solar noon with <5% cloud cover. The GER 2600 collected measurements from over 500 bands of reflectance between 355 and 2600 nm.

Discriminate analysis techniques were used to identify and model up to twelve bands of reflectance from the ground-based data most useful for differentiating between individual herbicide treatments and untreated plots. Further analysis evaluated the classification accuracy of the models formed. Models were formed to differentiate between the nicosulfuron, dicamba + diflufenzopyr, 2,4-D, or bromoxynil plots and the untreated plots. These models were 100% accurate for classifying herbicide treated plots versus untreated plots. Furthermore, the two wavelengths incorporated into the 2,4-D and dicamba + diflufenzopyr models were very similar, but varied drastically from those wavelengths incorporated into the nicosulfuron and bromoxynil models. Models formed from the wavelengths composing the aerial images were at least 75% accurate for classifying specific herbicide treatments when compared to the untreated check. The variability between the reflectance readings of the atrazine or primisulfuron plots and the untreated plots was not great enough to form models. Although further research is needed, the inability of the discriminant procedures to select wavelengths for distinguishing the atrazine or primisulfuron plots from the untreated plots may indicate these herbicides could be used in remote sensing research with little impact on the corn crop’s reflectance response patterns.

LANCELEAF SAGE COMPETITION WITH HARD RED SPRING WHEAT AND SOYBEAN.
Mathew G. Carlson and Kirk A. Howatt, Graduate Research Assistant and Assistant Professor, North Dakota State University, Fargo, ND 58105.

Field studies were conducted to evaluate competition of lanceleaf sage (*Salvia reflexa* Hornem) with hard red spring wheat (*Triticum aestivum*) and soybean (*Glycine max*). Lanceleaf sage is an annual broadleaf found throughout the central United States. Lanceleaf sage has slowly moved throughout North Dakota. Hard red spring wheat and soybean are two common crops grown in North Dakota, and they represent crops that are solid seeded and grown in rows. In hard red spring wheat and soybean, 60x60ft plots were established. Eleven to twenty one-meter square quadrats were randomly selected throughout the plot to evaluate the competitiveness of lanceleaf sage. Six plots of wheat and four plots of soybean were used for the study. Weed-free and crop-free quadrats were included at each site. Emergence dates and plant populations were recorded for all species. Lanceleaf sage plant height, width, and primary branch number were taken every two weeks after emergence. At harvest, biomass and seed production were measured for each species. Lanceleaf sage was not competitive with wheat and did not reduce wheat yield. Wheat produced a thick dense canopy, which inhibited the growth and development of lanceleaf sage. Mortality of lanceleaf sage in wheat was as high as 100%. Soybean yield was 71% lower with 58 lanceleaf sage plants per m^2 emerging with soybean when compared to the weed free check. Lanceleaf sage that emerged at the same time as soybean was nearly four-fold more competitive than lanceleaf sage that emerged 5 days after soybean. Wider row spacing and warmer temperatures at crop emergence allowed lanceleaf sage to produce a wide plant architecture when it emerged with soybean. Mortality of lanceleaf sage in soybean was as high as 58%.

GROWTH ANALYSIS OF GIANT CHICKWEED (MYOSOTAN AQUATICUM) IN ALFALFA.

Scott Bollman and Michael P. Crotser, Undergraduate Research Assistant and Assistant Professor, Department of Plant and Earth Science, University of Wisconsin at River Falls, River Falls, WI, 54022.

Giant chickweed (*Myosotan aquaticum*) has been confirmed as a weedy species in pastures, forage legumes (alfalfa) and turfgrass areas in several Wisconsin counties. A study was conducted in the field to model giant chickweed growth.. The experiment was a split plot design with four replications. Sub-plot treatments were weeks of giant chickweed growth and whole-plot treatments were bare ground or established alfalfa. Giant chickweed plants were grown under greenhouse conditions and transplanted into the field on June 12, 2001. Giant chickweed above ground parts were harvested weekly and relative growth rate, leaf area, leaf area ratio, and biomass accumulation were determined. Relative growth rate was analyzed using ANOVA procedure of SAS and means separation was conducted using Fisher's protected LSD test. Leaf area, leaf area ratio and biomass were subjected to regression analysis. Relative growth rates were greatest with early season growth of giant chickweed and daily average temperatures were correlated with reduced relative growth rate values. Giant chickweed biomass and leaf area increased, but leaf area ratio decreased over time.

GLUE RETAINS SEEDS IN SHATTER-PRONE WEED SEEDHEADS. Gary Amundson, Ebandro Uscanga, and Frank Forcella; Engineering Technician, Graduate Research Assistant, and Research Agronomist. USDA-ARS, Morris, MN 56267 and University of Minnesota, St Paul, MN 55108.

Four non-toxic and biodegradable glues each were sprayed at four concentrations onto maturing seedheads of redroot pigweed in an effort to retard seed shattering but still allow normal seedhead maturation. There were eight plants (seedheads) in each treatment, and half of these were enclosed in mesh bags to retain shed seeds. The study was conducted in a natural pigweed infestation at the West Central Research and Outreach Center, Morris, MN, during September 2001. Relative to control plants (no glue applied), treated plants appeared equally healthy and their seedheads contained about 10% more seeds at the time of harvest. These results can be interpreted to mean that glue applications were, in fact, non-toxic and allowed seedheads to mature without shedding seeds prior to harvest. Non-toxic glues applied before seed shed may aid weed researchers to more easily study fecundity of weed species with shatter-prone seedheads.

EMERGENCE DATE AFFECTS GROWTH AND FECUNDITY OF PIGWEEDS (*AMARANTHUS* SPP.). Ebandro Usganga, Frank Forcella, and Jeff Gunsolus; Graduate Research Assistant, Research Agronomist, and Professor, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108, and USDA-ARS, Morris, MN 56267.

Growth and fecundity of four pigweed species (redroot pigweed, Powell amaranth, common waterhemp, and prostrate pigweed) were evaluated in response to four simulated emergence dates at the Swan Lake Research Farm, Stevens Co., MN, during 2000 and 2001. Studies were conducted in both corn and soybean, as well as in the absence of any crop. In the presence of a crop, delayed pigweed emergence reduced rates of growth, adult plant sizes, and fecundities. This was true for all pigweed species. In contrast, in the absence of crops, plant sizes and fecundities were similar, within pigweed species, regardless of emergence date. Thus, some form of crop interference, most likely shading by the crop canopy, governed the negative effect of delayed pigweed emergence date on pigweed growth and seed production. Lacking crop interference, only with a premature end to the growing season (e.g., early frost) could the growth and fecundity of late-emerging pigweeds be penalized.

SITE PROPERTY VARIATION INFLUENCES VELVETLEAF RESPONSE TO SOIL-APPLIED HERBICIDE. Jeffrey W. Vogel, J. Anita Dille, Misti E. Tatro, and Gerard J. Kluitenberg, Undergraduate Research Assistant, Assistant Professor, Undergraduate Research Assistant, Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Velvetleaf can be a severe problem in Kansas cornfields causing 40-80% yield loss. Flumetsulam, a soil-applied ALS inhibitor, is used to control broadleaf weeds in corn. The objective of this study was to monitor early spring season emergence and growth of velvetleaf in response to two rates of flumetsulam across a landscape that varies in soil texture, soil organic matter, pH, and soil water content.

A field study was conducted in 2001 at Manhattan, KS. Four 200-m transects, in parallel with a related study (Tatro et al., this proceedings), were established in a no-till cornfield of varying soil properties on April 20. Fourteen 5-m plots were placed 10 m apart along the length of each transect. On April 27, approximately 500 velvetleaf seed were sown within 15 cm of the corn row and 2.5-cm deep in each of the 5-m plots. Two transects received a preemergence application of 76 g/ha flumetsulam, the recommended rate, while the other two received 19 g/ha, 0.25 the recommended rate. The herbicide was applied using a backpack sprayer with 8002 spraying tips and 187 L/ha. Cumulative emergence counts were taken at 5, 7, 11, 14, and 18 days after planting (DAP). At 7 and 14 DAP, velvetleaf were marked to be harvested and weighed at 18 DAP. Untreated velvetleaf were also marked and harvested, under the same guidelines, from the neighboring transects that were within 4 m of the herbicide treated transects. Soil pH, organic matter, soil moisture content, and texture were also obtained from the neighboring transects.

Variable patterns in emergence were observed across the transects at 5, 7, and 11 DAP. At 14 DAP, a higher level of emergence occurred across all transects and an average of 30% velvetleaf had emerged. During 6-9 DAP, 71 mm of rain fell causing the flush of velvetleaf. Flumetsulam began to affect cumulative emergence at 18 DAP; the number of emerged and surviving velvetleaf dropped to an average 25%. There were no differences in emergence patterns between the recommended and the 0.25 rate because flumetsulam did not prevent velvetleaf germination and emergence. In 67% of the plots, an increasing rate of flumetsulam decreased the average per-plant dry weight. Across the four transects the difference in dry weight reduction in response to flumetsulam rate was not consistent. In some locations in the field, the recommended and 0.25 rate produced equivalent per-plant velvetleaf dry weights. This indicates the ability to adjust rates and still obtain adequate control for this field site. Soil pH varied from 6.6 to 7.8, organic matter varied from 1.8 to 2.6%, and clay content varied from 16 to 34% across the transects. No single soil property interacting with flumetsulam described the velvetleaf response. Additional data analysis will improve our understanding of how multiple soil properties interacted with flumetsulam and how the response varied in space.

EFFECT OF DELAYED WATERHEMP EMERGENCE IN SOYBEAN ON GROWTH AND FECUNDITY. Robert G. Hartzler, Bruce A. Battles and Dawn E. Refsell, Professor, Research Associate and Graduate Assistant, Department of Agronomy, Iowa State University, Ames, IA.

Four experiments were conducted in central Iowa during the 1998 and 1999 growing seasons to evaluate the effect of delayed waterhemp emergence in soybean planted in 0.76 cm rows. Four emergence cohorts were established in each experiment: 1) waterhemp emerging immediately after planting (approximately 14 days after planting (DAP)), 2) waterhemp emerging at two trifoliate soybean stage (25-30 DAP), 3) waterhemp emerging at four trifoliate soybean stage (38-42 DAP), and waterhemp emerging at six trifoliate soybean stage (48-52 DAP). A total of sixty plants per cohort were identified shortly after emergence and monitored throughout the growing season. Percent survival, biomass accumulation and fecundity of the cohorts were determined.

Waterhemp survival averaged over the four locations was 91, 72, 52 and 19% for the first, second, third and fourth cohorts, respectively. At three sites, the first waterhemp cohort averaged approximately 300 g dry matter per plants, whereas at the other location waterhemp emerging shortly after planting accumulated more then 1.3 kg per plant. Waterhemp growth parameters were combined from the three locations with lower biomass acummulation due to similarity in growth and response to delayed emergence, whereas the fourth site was analyzed separately. At the three sites with similar responses, biomass was reduced 79, 95 and 99% when emergence was delayed until the V2, V4 and V6 soybean stage, respectively. At the other site, emergence delays resulted in 45, 78 and 90% reductions in biomass. Plants emerging shortly after planting at the sites with lower productivity averaged approximately 320,000 seeds per plant. At the fourth location, the first cohort averaged more than 2 million seeds per plant, with one plant producing more than 5 million seeds. Reductions in seed production due to delays in emergence was closely correlated to biomass reductions.

Delays in waterhemp emergence in relation to soybean planting resulted in rapid reductions in biomass accumulation. Due to the reduced biomass, waterhemp plants emerging after the V4 stage of soybean are unlikely to significantly affect soybean yields in most settings. However, due to the prolific seed production of this species, late-emerging weeds may maintain or build the seedbank.

RELATIVE COMPETITIVE INDICES OF ANNUAL WEEDS USING CROP LOSS ESTIMATES. Kathrin Schirmacher and J. Anita Dille, Graduate Research Assistant and Assistant Professor, Agronomy Department, Kansas State University, Manhattan, KS 66506.

Environmental and social impacts of herbicide usage have been heavily debated. The integration of a Decision Support System (DSS) into given management strategies shows great potential for reducing the amount of herbicide applied, improving management methods, and assessing crop yield losses resulting from weed interference. The DSS currently being developed in Kansas lacks competitiveness information on multiple weed species. Refining this information database will lead to the validation of a more effective weed management tool. The objective is to determine the competitive indices of six selected annual Kansas weed species based on crop and weed growth, weed biomass, weed volume, and crop yield. A field study was conducted in 2001 at Ashland Bottoms Agronomy Research Farm. Common sunflower, giant foxtail, large crabgrass, Palmer amaranth, shattercane, and velvetleaf were sown immediately after corn planting on May 15, 2001. Plots were 8-m long by 3 corn rows wide. Weeds were sown within 0.10 m of the center row for a length of 4 m. Emerged seedlings were thinned to a density of 10 plants m^{-1} of corn row. Corn and weed height, canopy diameter, and leaf numbers were noted every 7 to 10 days. Corn was harvested on September 30, 2001 from 3 m of the center row, threshed, dried, and adjusted to 15.5%. Corn and weed height, weed leaf and tiller number, and weed volume data were fit to a sigmoidal response curve relative to days after planting. Species were ranked according to their influence on measured variables. Maximum corn height varied from 197 cm to 226 cm, with corn being the shortest in the stand of common sunflower. Weed height at the end of the growing season was 196 cm for common sunflower, followed by Palmer amaranth, velvetleaf, shattercane, giant foxtail, with large crabgrass being the shortest at 35 cm. Similar rankings were noted for leaf numbers, volume, and biomass measurements. Large crabgrass had the greatest number of tillers followed by giant foxtail and shattercane. Corn yield varied from 157 kg ha^{-1} with common sunflower to 633 kg ha^{-1} with large crabgrass. Preliminary observations indicated that common sunflower interference was more substantial than the other weeds that were evaluated. Weed height, leaf number, volume, and biomass tended to be greater for the broadleaf species than the grasses. Accordingly, common sunflower, velvetleaf, and Palmer amaranth were ranked 1, 2 and 4, and giant foxtail was ranked third in terms of crop yield.

INFLUENCE OF SHATTERCANE INTERFERENCE ON CORN YIELD AND NITROGEN UPTAKE. Sarah R. Hans and William G. Johnson, Undergraduate Student Assistant, and Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65201.

Field experiments were conducted to determine the impact of shattercane (*Sorghum bicolor*) interference on corn (*Zea maize*) yield and nitrogen uptake in 1999 and 2000 near Columbia, MO on a Mexico silt loam with 2.6 % organic matter and pH 5.4 in fields with natural levels of shattercane infestations. Corn 'Dekalb 626RR' was planted using conventional-till methods. Atrazine was applied on all plots PRE at 2.76 kg a.i./ha and EPOST (3 to 8 cm grass) at 1.84 kg a.i./ha. Shattercane, corn, and soil were collected when the shattercane was 8, 15, 23, 30, or 46 cm tall, at tasseling (in 2000), and at corn harvest. Corn yields responded differently to environments. Corn yields were greater in 2000 than in 1999 due to more suitable growing conditions. In both years corn yields were reduced by shattercane interference when allowed to reach 30 cm tall before removal. In both years, shattercane contained more nitrogen than the corn on a per acre basis through the 30 cm shattercane removal timing. Yields from treatments in which the shattercane was allowed to compete until 12-inches tall before removal were approximately 76% of the weed free control. Season long shattercane interference resulted in an 86% yield loss in 1999 and a 42% yield loss in 2000. In 1999, corn in the untreated control had 87% less nitrogen than the weed free control at harvest. In 2000, corn in the untreated control had 51% less nitrogen than the weed free control at harvest. Shattercane interference resulting in reductions in per acre nitrogen levels in corn at harvest also resulted in yield reductions in both years.

INTEGRATION OF TECHNOLOGIES FOR HIGH ACCURACY WEED MAPPING IN LARGE PRODUCTION FIELDS. Richard D. Dirks Jr., Kevin D. Gibson and Case R. Medlin, Research Associate and Assistant Professor of Weed Science, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907-1155, Assistant Professor of Weed Science, Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK 74078-6028

Site-specific management programs require the accurate and precise identification of problem weeds within a field; however this can be a time consuming and labor intensive task. Automation of this process offers researchers a tool to map large production fields with a high degree of accuracy in a timely manor. We are in the process of developing and testing a system to provide such automation. The integration of three technologies (vegetation-sensing devices, centimeter-accuracy global positioning system and digital video cameras) allows the detection of weeds present between crop rows and the automated collection of georeferenced images. The Patchen WeedSeeker®sensors detect weeds and trigger a digital image capture system to gather an image of the targeted weed. Using a fixed base station, mobile station and radio transceivers, a real-time kinematic GPS system provides centimeter accuracy coordinates for each captured image. Images are labeled with GPS coordinates and stored in a computer database. Species identification is done post-process in the lab using the stored images. Once the data has been processed, a species-specific map can be created to investigate ecologically based questions. This system may be used to analyze ecological interactions among weed species, relative weed competitiveness, and environmental parameters. This system may also be used to study weed seed bank dynamics or to evaluate the economic potential of site-specific weed management.

SPATIAL VARIATION IN VELVETLEAF EMERGENCE AS INFLUENCED BY SOIL MOISTURE AND TEMPERATURE. Misti E. Tatro, J. Anita Dille, Jeffery W. Vogel, and Gerard J. Kluitenberg, Undergraduate Research Assistant, Assistant Professor, Undergraduate Research Assistant, and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Velvetleaf emerges in the spring in flushes. In order to control velvetleaf post-emergence effectively, information about where and when it emerges is important. The objective of this study was to determine how soil temperature and soil moisture affect the timing and location of velvetleaf emergence across the field. Soil physical properties play an important role in soil temperature and moisture and were explored to support this objective.

Studies were conducted in the field across two 200-m transects. Corn was no-till planted on April 20, 2001. Thermocouple probes were placed 2.5 cm below the soil surface at 1-m intervals on April 25 and 26. In the center of each 1-m interval, 100 velvetleaf seed were sown in 30-cm lengths at a depth of 2.5 cm on April 27. Soil temperature was recorded at 4-h intervals over a 24-h period on April 28, May 2, and May 8. Gravimetric soil water content was also measured on those days at 1-m intervals. Emergence was recorded by counting seedlings with cotyledons unfolded at 5, 7, 11, 15 and 18 days after planting (DAP). Seedlings were removed each time. The field site was surveyed to document elevation along the two transects. Soil texture, organic matter, and pH were determined from samples (0- to 5-cm depth) collected at 1-m intervals.

The field site had a relative elevation change of 1.92 meters, with a high center from 53 to 120 meters along the transect. Clay content varied from 10 to 27%, organic matter ranged from 1.5 to 2.9%, and pH varied from 6.5 to 7.8 across both transects. Obvious patterns in cumulative velvetleaf emergence (ranging from 0% to 57%) appeared across both transects at 5, 7, and 11 DAP. By 14 and 18 DAP, minimal patterns in cumulative velvetleaf emergence appeared across the transects as most seedlings had emerged. During 6-9 DAP there was a total of 71 mm of rainfall for a four day period. Gravimetric moisture was 15.2% on April 28 (1 DAP), 14.1% on May 2 (5 DAP), and 20.6% on May 8 (11 DAP). Average soil temperature was 22 C at 1 DAP and 18 C at 11 DAP over a 24-h cycle. Based on non-spatial correlation analysis, there were positive relationships between clay content and soil temperature measured on May 8 at 2:00, 6:00, and 10:00 p.m. Transect two showed a strong negative correlation between cumulative emergence at 11 DAP and clay content. Through additional non-spatial and spatial analysis, we expect to further identify how these key soil physical factors drive soil temperature and moisture variation across the two transects to influence velvetleaf emergence.

NATURE OF BIENNIAL WORMWOOD COMPETITION IN SOYBEAN AND DRY BEAN.
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Biennial wormwood has become an important weed of several crops within the north central region of the United States and southern Canada. Though little is known about the biology and competitive nature of biennial wormwood, infestations have mostly been associated with soybean and dry bean production. Studies were conducted to determine the emergence pattern of biennial wormwood in soybean at Fargo, ND, and in pinto bean at Minot, ND, under conventional tillage conditions. Emergence patterns of common cocklebur, kochia, and redroot pigweed were also monitored and compared to that of biennial wormwood. At both locations, the seedbed was disked two days prior to seeding of soybean on May 30 at Fargo and pinto bean on June 2, 2001 at Minot in 76-cm-wide rows. Weed emergence was monitored periodically until July 31 in 0.1-m^2 quadrats placed randomly within plots.

Biennial wormwood seedlings at Fargo began to emerge when percentage emergence for redroot pigweed and common cocklebur was 60 and 85%, respectively. The pattern of biennial wormwood seedling emergence at Minot was identical to that of kochia. At both locations, 80% of biennial wormwood seedlings emerged within 7 to 10 days whereas maximum percentage emergence occurred after 17 days. Biennial wormwood at Fargo emerged slower than common cocklebur and redroot pigweed, but subsequent control generally was lowest where common cocklebur was prevalent. Apparently the wide canopy of common cocklebur intercepted more postemergence herbicide than redroot pigweed, thereby resulting in the lowest biennial wormwood control where common cocklebur was present. The increase in biennial wormwood populations probably is due in part to late emergence after the last herbicide treatment and/or avoidance of herbicide contact under the canopy of crop and weeds.

MANAGING COMMON CHICKWEED AND PURPLE DEADNETTLE WITH FALL AND EARLY-SPRING HERBICIDE TREATMENTS. Mark M. Loux and Anthony F. Dobbels, Associate Professor and Research Associate, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210.

Field studies were conducted at three sites to determine the effectiveness of late-fall and early-spring herbicide treatments for management of common chickweed and purple deadnettle in no-tillage corn or soybeans. Fall treatments were applied between mid- and late November of 2000, and spring treatments were applied in late March of 2001. Treatments were evaluated for weed control in late April of 2001. Across all sites, soybean herbicides were generally more effective when applied in the fall, compared to spring application. Soybean herbicides applied in the fall that controlled at least 90% of both common chickweed and purple deadnettle included: glyphosate alone at 840 g/ha; glyphosate at 630 g/ha in combination with imazethapyr, imazaquin, or metribuzin; glyphosate at 420 g/ha in combination with 2,4-D ester; chlorimuron ethyl plus tribenuron methyl plus 2,4-D ester; and metribuzin plus paraquat plus 2,4-D ester. Soybean herbicides applied in spring that controlled at least 90% of both weeds included: metribuzin plus 2,4-D ester and chlorimuron ethyl plus tribenuron methyl plus 2,4-D ester. Corn herbicides were effective on common chickweed and purple deadnettle when applied in fall or spring. Corn herbicides applied in fall that controlled at least 90% of both weeds included: metribuzin plus simazine plus 2,4-D ester; tribenuron methyl plus simazine plus 2,4-D ester; and thifensulfuron plus rimsulfuron plus 2,4-D ester. Corn herbicides applied in spring that controlled at least 90% of both weeds included: atrazine plus 2,4-D ester; atrazine plus carfentrazone; atrazine plus isoxaflutole; and atrazine plus mesotrione.

SURVEY OF PROBLEM WEEDS IN INDIANA. Glenn R.W. Nice, Thomas T. Bauman, Ronald L. Blackwell, and Case R. Medlin, Purdue University, West Lafayette, IN; and Oklahoma State University, Stillwater.

A survey of problematic weeds in Indiana corn and soybean fields was conducted by Purdue University Weed Science Extension Specialists in conjunction with the County Extension Educators to monitor trends and perceptions of weed control issues in Indiana. Questionnaires were completed within each respective county by the county agent, prominent producers, and custom applicators. The most problematic weeds in 2000 (by weighted score) were: giant ragweed (*Ambrosia trifida*), Canada thistle (*Cirsium arvense*), johnsongrass (*Sorghum halepense*), common lambsquarters (*Chenopodium album*), shattercane (*Sorghum bicolor*), hemp dogbane (*Apocynum cannabinum*), burcucumber (*Sicyos angulatus*), velvetleaf (*Abutilon theophrasti*), common ragweed (*Ambrosia artemisiifolia*), and common cocklebur (*Xanthium strumarium*). Giant ragweed and Canada thistle were rated as increasing problems. Herbicides most widely used to control these weeds in 2000 (ranked by weighted score) were glyphosate, atrazine, 2,4-D, metolachlor, and nicosulfuron. Nicosulfuron, primsulfuron, 2,4-D, and prosulfuron + primsulfuron were being used in place of more atrazine. Forty-nine percent of the corn growers and 32% of the soybean growers were pleased with their preemergence weed control. Eighty percent of the corn growers and 90% of the soybean growers were pleased with their postemergence weed control programs. Forty percent of the respondents indicated increasing problems from herbicide drift. A majority of the survey participants, 68%, reported no-till and reduced-tillage systems were contributing to perennial weed problems, while 33% attributed increasing annual weed problems to these tillage practices. The survey was not an attempt to measure market share of the various herbicide products and was based solely on the perceptions and opinions of the individuals who responded to the survey.

THE EVOLUTION OF WEEDSOFT. Brady F. Kappler and Lynn B. Bills, Extension Educator and Software Designer, Department of Agronomy and Horticulture, University of Nebraska, Lincoln, NE 68583

From it's NebraskaHERB roots in 1992 to the latest 2002 version WeedSOFT has evolved into a robust and useful computer program. WeedSOFT is a decision support system (DSS) designed to assist growers, agronomic professionals and extension personnel in making both proactive and reactive weed management decisions. This comprehensive, and ecologically sound, tool helps farmers in every step of their weed management decision. WeedSOFT provides the treatment information according to specific field conditions while factoring in economic and environmental principles. The program considers early season soil applied treatments, control of mid-season infestations, or compares treatments requiring additional costs for herbicide resistant crops.

In 1992 the University of Nebraska unveiled the DOS based NebraskaHERB 1.0 which while revolutionary, could only be used in soybeans for postemergence recommendations. From 1993 to 1995 the program progressed to version 4.0 and added corn, sorghum, wheat, and sugarbeet postemergence recommendations along the way. In 1996 the NebraskaHerb name was changed to WeedSOFT. This change reflected a new program that was Windows compatible and now also provided pre-emergence recommendations in addition to the postemergence recommendations. Also with WeedSOFT 1.0 two new modules were added in addition to the "advisor" recommendation module. EnviroFX and WeedView were new modules that brought expanded information to the user. EnviroFX provided the user with environmental information and leaching potential of certain herbicides based on the soil characteristics. WeedView provided pictures and basic descriptions of many common weeds found in Nebraska. In 1997 WeedSOFT 2.0 was released and added a fourth module known as MapView. MapView allowed the producer to see specific groundwater vulnerability threats from herbicides in his particlular location. In 1999 work began on regionalization of WeedSOFT to the Midwest rather than just Nebraska. A USDA grant provided the necessary startup funds to begin the development of other state version of WeedSOFT. In this initial phase Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, and Wisconsin were the participating partners. In 2000 WeedSOFT 5.0 was for the first time released on CD instead of floppy disks. In 2001 the design platform was changed to Visual Basic. In addition, a web page was developed (http://weedsoft.unl.edu) to provide information, technical support, and deliver updates to users. In 2002, a new yield loss algorithm has been developed for WeedSOFT 2002 based on field validation research at Nebraska and other states. Also the program will include an error logging function for tracking errors and assisting in technical support. The regional project will also be entering the distribution phase with Illinois, Kansas, Missouri, and Wisconsin releasing their own "state" version for the first time. In the future, the core program will continue to be developed and improved for utility and ease of use. Also Indiana and Michigan will release their state versions in 2003. The goal is to dramatically increase the distribution of WeedSOFT and in the future more states may be added to the regional project.

RESIDUAL ACTIVITY OF FALL-VERSUS SPRING-APPLIED HERBICIDES IN NO-TILL SOYBEANS IN MICHIGAN AND OHIO. Chad D. Lee and Mark M. Loux, Academic Specialist, Department of Crop and Soil Sciences, Michigan State University, East Lansing MI 48824, and Professor, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210.

Populations of winter annual weeds in no-till fields have increased over the past several years. A study was conducted in 2001 in Ohio and Michigan comparing weed control following fall versus spring herbicide applications. The objectives were to determine which herbicide programs prevent the need for a spring burndown herbicide and which herbicide programs provide residual control of summer annual weeds throughout the growing season. Herbicide programs investigated included glyphosate at 841 g ae ha^{-1}, chlorimuron ethyl + metribuzin + tribenuron methyl at 28 + 115 + 5.25 g ai ha^{-1}, chlorimuron ethyl + sulfentrazone + tribenuron methyl at 26.9 + 132 + 5.25 g ai ha^{-1}, imazaquin + glyphosate at 101 + 628 g ae ha^{-1}, imazethapyr + glyphosate at 70 + 628 g ae ha^{-1}, flumetsulam + metribuzin at 56 + 210 g ai ha^{-1}, paraquat + metribuzin 701 + 210 g ai ha^{-1}, and metribuzin at 421 g ai ha^{-1}. Each herbicide program included 2,4-D at 560 g ai ha^{-1} and each program was applied in the fall (FALL), the early spring (SPRING) (42 d pre-plant (DPP) in Ohio and 20 DPP in Michigan), and at 7 DPP. Weeds were allowed to compete until soybeans reached R1 growth stage at which time glyphosate at 841 g ae ha^{-1} was applied. In Ohio, all FALL programs provided 100% control of common chickweed, while all SPRING programs except metribuzin provided 98% control of common chickweed. Only glyphosate and paraquat + metribuzin applied 7 DPP provided greater than 98% control of common chickweed at planting. Similar observations between FALL, SPRING, and 7 DPP applications on winter annuals were observed in Michigan. Giant ragweed control at 28 d after planting (DAP) in Ohio, was greater than 75% for FALL applications containing chlorimuron ethyl or imazaquin. SPRING applications of chlorimuron ethyl + sulfentrazone + tribenuron methyl, imazethapyr + glyphosate, and flumetsulam + metribuzin provided greater than 75% control of giant ragweed. However, all 7 DPP programs except metribuzin provided greater than 90% control of giant ragweed. In Michigan, the loss of residual activity in FALL programs was most evident with annual grasses. Control of annual grasses 28 DAP was less than 70% for all FALL herbicide programs, while SPRING programs containing chlorimuron ethyl or imazethapyr provided greater than 80% control. All 7 DPP programs except glyphosate and paraquat + metribuzin provided at least 80% control of annual grasses. In most cases, soybean yield was not impacted by herbicide programs or timing of those programs. Most herbicide programs provided better winter annual weed control at planting when applied FALL or SPRING compared to 7 DPP. Most herbicide programs provided better summer annual weed control when applied closer to planting. Applications made in the early spring may be the best balance between controlling winter annual weeds before planting and providing residual activity of summer annuals through the growing season.

FALL HERBICIDE APPLICATIONS IN CORN AND SOYBEAN. Bryan G. Young and Ronald F. Krausz, Assistant Professor and Researcher, Department of Plant, Soil and General Agriculture, Southern Illinois University, Carbondale, IL 62901.

Two separate field studies were conducted twice in corn and soybean from 1999 to 2001. The corn study evaluated the efficacy of the following herbicides applied in the fall: simazine, rimsulfuron & thifensulfuron, metribuzin, 2, 4-D, and flumetsulam. Rimsulfuron & thifensulfuron applied in the fall controlled 44 to 50% of wild garlic at planting. All other herbicide combinations provided little to no wild garlic control. All herbicide combinations resulted in 84% or greater control of henbit in 2000 and 100% control in 2001. Control of mouseear chickweed was 95% or greater from all herbicide treatments in both years. Annual bluegrass and Carolina foxtail control was 88% or greater from rimsulfuron & thifensulfuron and simazine. All other herbicide treatments provided less than 60% control of these grass species. Corn yield was similar for all herbicide treatments in both years.

The objective of the soybean study was to compare the efficacy of fall herbicide applications to traditional spring applications (30 EPP) for control of winter annual weeds in a no till versus a fall tillage system. Fall tillage (disking) was performed prior to any herbicide applications. Soybean herbicide treatments evaluated were chlorimuron & sulfentrazone, thifensulfuron & tribenuron, flumetsulam plus metribuzin, and chlorimuron & metribuzin plus 2,4-D. In 2000, control of henbit was determined by the interaction of tillage, herbicide application timing, and herbicide treatment. Thifensulfuron & tribenuron provided 73% or less control of henbit. All other herbicide treatments provided 83% or greater control of henbit. When fall tillage was used, spring applications of rimsulfuron & thifensulfuron provided greater control of henbit compared to fall applications. Henbit control was similar from rimsulfuron & thifensulfuron at both application timings in no till. In 2001, fall tillage improved control of henbit from fall applications of flumetsulam plus metribuzin and thifensulfuron & tribenuron compared to no till. Similar to henbit control in 2001, control of mouseear chickweed was improved when fall tillage was used compared to no till averaged over all herbicides. Tillage did not affect the efficacy of spring herbicide applications. Fall tillage improved control of mouseear chickweed from chlorimuron & sulfentrazone by 20% compared to no till. In 2000, there was no difference in soybean yield due to tillage, application timing or herbicide treatment. Soybean yields were 14% greater in no till compared to fall tillage averaged over herbicide and application timing in 2001. Application timing did not influence soybean yield in 2001.

MICRONUTRIENT INTERACTIONS REDUCE GLYPHOSATE EFFICACY ON TALL FESCUE. Michael V. Hickman, Darrin M., Dodds, and Don M. Huber, Adjunct Assist. Professor, Graduate Research Assistant and Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

A desire to reduce input costs by combining post-emergent herbicide applications with foliar fertilizer applications lead to the experiments presented. Treatments were glyphosate herbicide with fertilizer solutions of iron, zinc, copper, magnesium, or manganese. Treatments were applied to actively growing, well established, Tall Fescue at a rate of 0.63 kg ae/ha. Treatments were applied as tank mixtures or sequential applications with approximately 1 minute elapsed between them. Herbicide efficacy was assigned a rating based on visual estimations of control (0 to 9, 0=no effect, 9=complete necrosis). Evaluations were made 4 weeks after treatment. Addition of fertilizer to glyphosate as a tank mix always significantly reduced glyphosate efficacy compared to glyphosate alone. Tank mixes of glyphosate with iron, zinc, copper or magnesium reduced glyphosate efficacy to 25% of the glyphosate alone, and the manganese-glyphosate mixture reduced efficacy to 50% of glyphosate alone. While mixtures always reduced glyphosate efficacy, sequential applications of iron or zinc following glyphosate reduced efficacy. Sequential applications of glyphosate and magnesium, copper or manganese tended to reduce efficacy but not to a level of statistical significance. The results of these studies demonstrate that tank mixing glyphosate with fertilizer solutions is unwise and will result in substantial reductions in efficacy. Sequential applications made within minutes of each other may result in a substantial loss of herbicidal efficacy.

ALACHLOR AND METOLACHLOR METABOLITES IN CORN AND SOIL. Kassim Al-Khatib, Jolene Baumgartner Unland, Brian L. S. Olson, and David W. Graham, Associate Professor, Biologist, Extension Specialist, and Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506, Dow AgroSciences, Road, Indianapolis, IN 46268, NW Kansas State University, Colby, KS 67701, and Department of Civil and Environmental Engineering, University of Kansas, Lawrence, KS 66045.

Experiments were conducted in a growth chamber to study alachlor and metolachlor metabolism in soil and corn and determine if alachlor and metolachlor and their metabolites exudate from corn roots to the growth medium. Alachlor was more readily absorbed by corn than metolachlor. Absorption of alachlor and metolachlor were 72% and 55%, respectively, 10 days after seedling emergence (DAE). Alachlor and metolachlor were rapidly metabolized in corn, although metabolism rates were higher with metolachlor than alachlor. Ten similar alachlor metabolites were detected in roots and shoots. In addition, two metabolites were detected only in the shoots and one metabolite detected only in the roots. In general, metolachlor metabolism in corn produced fewer metabolites than alachlor. At five DAE, 10 and nine metabolites were detected in shoots and roots, respectively. Alachlor and metolachlor metabolism in soil showed similar patterns to metabolism in plant but produced fewer metabolites. One unique alachlor metabolite appeared in soil but not in plant. Roots of corn seedlings treated with ^{14}C-alachlor or ^{14}C-metolachlor released significant amounts of radioactivity to the surrounding growth medium five days after treatment. Plants treated with alachlor released more radioactivity than plants treated with metolachlor.

CUT SURFACE (TOP) AND BASAL APPLICATION OF HERBICIDES ON HIGH SIBERIAN ELM STUMPS. Wayne A. Geyer, Professor, Forestry Division, Kansas State University, Manhattan, KS 66506.

A study was conducted to test various herbicides in deadening the stumps of recently cut Siberian elm trees. Five chemicals were applied in early April at two levels on 18-inch high stumps; at the ground line or the cut surface top and treated 60 days later with a garden sprayer. Either the cut surface or the basal three inches of the trunk were sprayed to the point of runoff. Low volatile ester formulations were used at the following rates: dicamba + 2,4-D + dichclopyr at 5%, 2,4-D+ triclopyr at 5%, imazapyr RTU at 3%, fluroxypyr at 10%, and triclopyr at 5%. No treated control trees were selected.

Many sprouts were found with all treatments during the first growing season because of the later than desired application time of the chemicals. Residual stump height after cutting affects the number of live sprouts; at two years the number was higher with high stumps heights (75cm). After two years, we achieved nearly complete sprout control when the herbicide was sprayed at the base of the stump. When applied to the top of the trunk, imazapyr RTU at 3% and triclopyr at 5 gave good very good sprout control.

In conclusion all herbicides as tested in this study can be used to control sprouting on recently cut Siberian elm trees when applied at the tree base. When a tree is cut high at 18 inches above the ground, as compared to the usual lower cut at four inches, then selected herbicides may be used such as imazapyr and triclopyr.

GLYPHOSATE RESISTANT CORN PERFORMANCE AS INFLUENCED BY PLANT POPULATION AND ROW SPACING. Craig M. Alford* and Stephen D. Miller, Graduate Research Associate and Professor, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Producers in the North Platte Valley of Wyoming and Nebraska have grown corn in 76 cm rows at populations of 28 to 32,000 plants per acre for the past several years. An alternative to this system would be to produce corn and other crops in rows narrower than 76 cm. In a narrow row production system plants are more equidistantly spaced thus allowing for more efficient use of resources such as nutrients, water, and light. Several studies have reported the following advantages of a narrow row corn production system: higher yields, reduced herbicide inputs, improved weed control, decreased soil erosion, as well as more efficient use of light, water, and nutrients. There have been a significant number of studies conducted in other regions of the country relating to the production of corn in narrow rows (< 76 cm) but none in the northern Great Plains.

A study was established to investigate the effects of row spacing, plant population and herbicide treatment on the production of glyphosate tolerant corn under irrigated conditions. Corn was planted in 38, 56, and 76 cm rows at three population, 39,500 79,000 and 118,500 seed per acre. Each of these combinations was then treated with five herbicide treatments: a pre-emergence application of metolachlor/atrazine, a single application of glyphosate, two applications of glyphosate, a hand weeded, and a weedy check. The study was setup as in a split plot factorial arrangement with four replications. Reducing row width or changing population had no significant impact on corn yields. All of the herbicide treatments yielded significantly better than the weedy check. However, weed biomass was significantly higher in the low population, wide row treatments. Increased plant populations and decreased row spacing allowed for earlier canopy closer and reduced light infiltration. Herbicide treatment significantly impacted weed biomass with the weedy check, and the single application of glyphosate producing the greatest amounts of weed biomass.

MANAGEMENT OF VOLUNTEER GLYPHOSATE-RESISTANT WHEAT IN GLYPHOSATE-RESISTANT CORN. Shannon M. Oltmans, Richard K. Zollinger, and Robert A. Henson, Graduate Research Fellow, Associate Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105, and Research Agronomist, North Dakota State University Research Extension Center, Carrington, ND 58421.

Glyphosate-resistant wheat may be available to growers within 2 to 4 years. Additional herbicides must be applied with glyphosate to control volunteer glyphosate-resistant wheat in glyphosate-resistant crops. The objectives of this experiment were to evaluate corn injury from glyphosate tank-mixes, and control of volunteer glyphosate-resistant wheat and other weeds in glyphosate-resistant corn.

The experiment was a randomized complete block design with four replicates per treatment. There were 10 treatments including an untreated at two locations, Prosper and Carrington, ND, in both 2000 and 2001. Treatments were applied to corn mid-postemergence at 2 to 4 collar and late-postemergence at 6 to 8 collar stages. Weed species present were common lambsquarters, common ragweed, green and yellow foxtail, redroot pigweed, volunteer glyphosate-resistant wheat, wild buckwheat, and wild mustard. Data presented are weed control ratings from 28 days after treatment (DAT) and phytotoxicity ratings from 7 and 30 DAT. Means were separated using Fischer's Protected LSD.

Corn injury 7 DAT in 2000 ranged from 4 to 22%, but injury 30 DAT declined to 1 to 7%. Corn injury was greatest in treatments that contained nicosulfuron&rimsulfuron&atrazine and rimsulfuron&thifensulfuron, which may have resulted from environmental stress. Corn injury 7 DAT in 2001 ranged from 3 to 7%, but by 30 DAT injury declined to 1 to 6%. All treatments 28 DAT provided greater than 96% common lambsquarters, 92% common ragweed, 91% redroot pigweed, and 98% wild mustard control. Wild buckwheat control ranged from 86 to 99%, with split-applied glyphosate treatments providing greater than 90% control. Foxtail control ranged from 54 to 96%, with split-applied glyphosate treatments providing greater than 89% control. All treatments had greater than 91% volunteer glyphosate-resistant wheat control, except glyphosate plus ammonium sulfate plus atrazine plus petroleum oil followed by glyphosate plus ammonium sulfate, which provided 8% control. Split-applied glyphosate treatments provided the greatest weed control, because they controlled late-emerging flushes of weeds.

WEED CONTROL IN GLYPHOSATE RESISTANT ECOFALLOW CORN. Robert N. Klein and Jeffrey A. Golus, Professor and Extension Research Technologist, University of Nebraska, North Platte, NE 69101.

A study was conducted to evaluate various combinations of preemergence and postemergence herbicides in glyphosate resistant ecofallow corn. The field was located near North Platte, NE on the West Central Research and Extension Center Dryland Farm. The soil had a pH of 5.1, 1.7% organic matter and a percent sand-silt-clay of 44-32-24. Sixteen treatments were laid out in randomized complete block design. All treatments were applied with a tractor sprayer with a fifteen foot boom (six 11003XR nozzles on 30 inch spacing). Nozzle pressure was 20 psi, carrier volume 10 gpa and speed 4.1 mph. The corn was planted on May 2 at 16,900 seeds per acre in 30 inch rows, and was hybrid DK580RR. Preemergence treatments were applied on May 8. Postemergence treatments were applied on June 22, with the following weeds present: green foxtail up to seven inches tall, witchgrass up to four inches, sandbur up to four inches, kochia up to six inches, and the corn being 10 inches tall. The plot was hailed on May 31. Weeds were counted in all plots on June 21, July 5 and July 27, and percent control calculated. The plots were harvested on October 23.

Treatments that gave 96% or more green foxtail control on July 27 included postemergence treatments containing glyphosate, fluroxypyr plus glyphosate, metolachlor plus atrazine preemergence plus glyphosate postemergence, and an experimental plus atrazine preemergence. These treatments also gave 99 to 100% control of sandbur on July 27. All treatments provided 99% or greater control of witchgrass on July 27, except an isoxaflutole plus atrazine treatment (0.059 lb ai/a plus 1) at 92%. All treatments gave 97% or better control of kochia on July 27. Three treatments, which included the check, isoxaflutole at 0.07 preemergence, and experimental preemergence plus diflufenzopyr + dicamba at 0.24 postemergence yielded significantly less than the top yielding treatment (137 bu/a) at the 5% level.

ECONOMIC COMPARISON OF HERBICIDE RESISTANT CORN TECHNOLOGIES. David E. Hillger, Thomas T. Bauman and Michael D. White, Graduate Research Assistant, Professor and Research Associate, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

The 2001 season was the second year of a two-year study to determine if there is measurable profitability of glyphosate resistant (Roundup Ready®), glufosinate resistant (Liberty Link®) and imidazolinone tolerant (Clearfield®) technologies in conventional tillage. Results presented are from studies conducted at three locations in Indiana; Purdue Agronomy Research Center, (ARC), West Lafayette, IN, Pinney Purdue Agriculture Center, (PPAC), Wanatah, IN and Northeast Purdue Agriculture Center, (NEPAC), Columbia City, Indiana. Herbicide treatment and corn hybrid selections were based on the recommendations of industry representatives from the respective companies. In the 2000 season, four herbicide treatments, one conventional and three technology specific, were applied on two corn hybrids of each technology. For the 2001 season, eight treatments, two conventional and six technology specific, were applied to same hybrids used in 2000 season. Herbicide rates were adjusted for the characteristics at each location. Yields were compared across technologies using the common conventional treatments and within each technology using all treatments. The results of the 2000 season were that all herbicide treatments provided good weed controls regardless of technology therefore weed competition had no affect on crop yield. Analysis of the yields from plots treated with s-metolachlor & atrazine (Bicep II Magnum®) followed by dicamba & atrazine (Marksman®), the common treatment for all technologies, showed no differences due to technologies but differences between hybrids were found at all locations. The different herbicide treatments had no effect on yield in the Roundup Ready®, Clearfield® or traditional system. No difference in yield was seen due to herbicide treatment with one of the Liberty Link® hybrids. However, yield from the other Liberty Link® hybrid treated with Bicep II Magnum® followed by Marksman® was less than the other Liberty Link® treatments. The growing conditions of the 2001 season provided many challenges including reduced activity of some of the pre-applied and single post applied herbicides, which resulted in the presence of weeds at harvest. However, this weed pressure did not an affect the final corn yield. The 2001 results found that the yields from plots treated with Bicep II Magnum® followed by Marksman® showed no differences due to technologies. Plots treated with acetochlor, atrazine & isoxaflutole (Harness Xtra® & Balance Pro®), the second common treatment among technologies, showed differences among the technologies and hybrids at ARC but not at the other locations. The different herbicide treatments had no effect on yield in the Roundup Ready®, Liberty Link® or Clearfield® system however, differences in yield were observed due to herbicide treatments within the conventional hybrids at ARC only. Conclusions from this two year study indicates that: 1) hybrid selection for a location is the primary factor that influences gross profitability of corn production, and 2) net profit can be increased by matching the proper herbicide program with that hybrid and observed weed pressure for that location.

EVALUATING POSTEMERGENCE WEED CONTROL OPTIONS IN HERBICIDE RESISTANT CORN HYBRIDS: A TWO YEAR, MULTI-STATE SUMMARY. Karen A. Zuver and James J. Kells, Graduate Research Assistant and Professor, Department of Crop and Soil Science, Michigan State University, East Lansing, MI, Case R. Medlin, Assistant Professor, Purdue University, West Lafayette, IN Mark M. Loux, Professor, The Ohio State University, Columbus, OH and Christy L. Sprague, Assistant Professor, University of Illinois, Urbana, IL.

Herbicide resistant hybrids offer additional options for weed control in corn. Growers need more information on the consistency of these new weed control strategies. Studies were conducted in 2000 and 2001 in Indiana, Illinois, Michigan, and Ohio to evaluate the consistency of weed control among herbicide strategies for imidazolinone-resistant (Clearfield), glufosinate-resistant (LibertyLink), and glyphosate-resistant (Roundup Ready) corn. In addition, these strategies were compared to typical preemergence and postemergence programs for conventional corn. Near-isogenic hybrids were utilized at each location to minimize variation in growth and yield potential among hybrids. Each study was designed as a split-plot with corn hybrid as the main plot and weed control strategy as the sub-plot. Hand-weeded and weedy plots were included in the experimental design. The preemergence program consisted of metolachlor + atrazine. The conventional postemergence program consisted of nicosulfuron+rimsulfuron + atrazine + dicamba. Imidazolinone-resistant corn was treated with imazapyr + imazethapyr + dicamba. Glufosinate-resistant corn was treated with glufosinate + atrazine. Glyphosate-resistant corn was treated with glyphosate + atrazine. Treatments were applied when weeds reached 5 to 10 cm. Application rates were adjusted for each location based on site characteristics and weed species. Velvetleaf was present at 7 of the 8 locations. Common lambsquarters and giant foxtail was present at 6 of the 8 locations. Other common species were amaranthus species, morningglory species, common cocklebur, common ragweed, and giant ragweed. Data were analyzed for consistency of control by species across all locations and years.

WEED POPULATION DYNAMICS IN GLYPHOSATE-RESISTANT CORN AND SOYBEAN CROPPING SYSTEMS. D. E. Stoltenberg, Associate Professor, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

Cropping systems are changing rapidly in the upper Midwest. Growers are increasingly adopting herbicide-resistant crop cultivars, particularly transgenic crops with resistance to glyphosate. Grower interest in glyphosate-resistant corn and soybean has rapidly and dramatically changed weed management practices. The potential exists on many acres where glyphosate is the primary, if not only, herbicide used for weed management in both corn-soybean rotation and in continuous-corn cropping systems. Although growers are implementing these new technologies, many questions remain about the long-term impact of glyphosate-resistant cropping systems on weed management. Little or no research information has been available to growers about the potential for new weed problems, weed resistance to glyphosate, or the integration of glyphosate use with other cultural, mechanical, and chemical practices. Therefore, research was initiated in 1998 and conducted through 2001 at the University of Wisconsin Arlington Agricultural Research Station to determine the weed management and agronomic risks in glyphosate-resistant corn and soybean cropping systems as influenced by primary tillage, crop rotation, and intensity of glyphosate use. Specific objectives were to determine changes over time in the number and type of weed species, weed plant density and biomass, soil seed bank density, and crop yield. Tillage treatments included moldboard plow, chisel plow, and no-tillage systems. Cropping system treatments included continuous corn and corn-soybean rotation. Weed management treatments included glyphosate only, glyphosate use integrated with other chemical and mechanical practices, and conventional herbicide programs. Among weed management treatments, glyphosate applied sequentially or glyphosate plus inter-row cultivation were among the most consistent and effective treatments in continuous corn. Results for these particular treatments indicate that total weed densities have decreased over time. In corn-soybean rotation, most treatments that included glyphosate were effective, particularly in moldboard plow and chisel plow systems. Common lambsquarters, giant foxtail, redroot pigweed, and velvetleaf were the dominant weed species in most treatments in each cropping system. However, in treatments that included broad-spectrum soil-residual herbicides, giant ragweed and shattercane densities increased dramatically over time. Results after 4 yr suggest that the weed management and agronomic risks associated with glyphosate use in glyphosate-resistant corn and soybean may be no greater than those associated with conventional herbicide programs.

EVALUATION OF WEEDSOFT IN MICHIGAN CORN. Corey J. Guza and James J. Kells, Graduate Extension Assistant and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Computerized weed management decision tools have the potential to improve weed control recommendations. Field studies were conducted in Michigan in 2000 and 2001 to test the accuracy of weed management recommendations from WeedSOFT Advisor in corn. Advisor is the computerized weed management component of the WeedSOFT program. Weed control and percent maximum corn yield from Advisor recommendations were compared to standard Extension recommendations and actual field results. Advisor was accurate in predicting redroot pigweed, common lambsquarters, and common ragweed control in 2000 and 2001. Velvetleaf control was lower than predicted with a bromoxynil treatment in 2000. Giant foxtail control was lower than predicted with a 2,4-D + atrazine treatment in 2001. Advisor accurately predicted percent maximum yield in 2000. In 2001 actual yields were lower than Advisor predicted for treatments of 2,4-D + atrazine and nicosulfuron + rimsulfuron + atrazine. Dry weather in the middle of the growing season may have contributed to the lower yields in 2001. Weed control recommendations from Advisor resulted in weed control and percent maximum corn yield equal to the standard Extension recommendations.

WEED MANAGEMENT IN STRIP TILLAGE CORN. Byron J. Hendrix, Bryan G. Young and She- Kong Chong, Graduate Research Assistant, Assistant Professor and Professor, Department of Plant, Soil and General Agriculture, Southern Illinois University, Carbondale, IL 62901.

Field studies were conducted in 2000 and 2001 to determine if differences exist in the time of weed emergence, the type of weed species emerging, weed density, weed control, and corn yield in a strip tillage production system compared to conventional and no tillage systems. Weed emergence peaked at two weeks after planting in 2000 and concluded at eight weeks after planting. In 2001, emergence peaked at four weeks after planting and concluded at six weeks after planting. Differences in weed emergence patterns between the two years could be attributed to differences in rainfall patterns and soil temperature. Emergence of giant foxtail, common waterhemp, velvetleaf and common cocklebur two weeks after planting in 2000 was greater in conventional tillage compared to no tillage and strip tillage. There was no effect of tillage system on giant foxtail and common waterhemp emergence in 2001. Similar to 2000, velvetleaf emergence two weeks after planting in 2001 was greater in conventional tillage. Cumulative emergence of all species was greatest in the conventional tillage plots in 2000. However, cumulative weed emergence was similar across tillage systems with the exception of velvetleaf for which emergence was greater in conventional tillage as compared to strip and no tillage systems in 2001.

Tillage systems were evaluated for weed control from a standard preemergence treatment of acetochlor & atrazine as well as a postemergence application of glyphosate. Control of giant foxtail and common waterhemp was significantly lower in no tillage compared to strip and conventional tillage in 2000 due to delayed corn canopy closure. In 2001, control of giant foxtail and common waterhemp from the preemergence program was reduced in both no tillage and strip tillage compared to conventional tillage. Control of common waterhemp in 2001 and giant foxtail in both years was similar with the postemergence program regardless of tillage system. Control of common cocklebur and velvetleaf was not effected by tillage system in either year.

Corn yield averaged across herbicide program was greatest in strip tillage in 2000 and conventional tillage in 2001. Differences in yield between tillage systems were likely due to corn establishment and growth and were not related to weed emergence or weed control.

WEED CONTROL SYSTEMS WITH AE F130360 (FORAMSULFURON) IN CORN. Jeffrey A. Bunting, Christy L. Sprague, and Dean E. Riechers, Graduate Research Assistant and Assistant Professors, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

AE F130360-01 (proposed name: foramsulfuron) and AE F130360-02 (proposed name: foramsulfuron plus iodosulfuron) are two new postemergence sulfonylurea herbicides being developed for postemergence control of both grass and broadleaf weeds in corn. In 2000 and 2001, four field studies were conducted in Illinois to examine the performance of AE F130360-01 and AE F130360-02 alone and in combination with other postemergence corn herbicides. Herbicide treatments included AE F130360-01 and AE F130360-02 each applied alone at 37 and 28 g/ha in 2000 and 37 and 38 g/ha in 2001, respectively. Adjuvant selection included a methylated seed oil and a nitrogen source. Each of these herbicides were tank-mixed with atrazine, dicamba, dicamba plus diflufenzopyr, and carfentrazone in 2000 with one additional tank-mixture in 2001 of mesotrione. The tank-mix partner rates were labeled field use rates and adjuvant selection was based on the tank-mix partner. Nicosulfuron was used as a standard comparison with AE F130360-01 and nicosulfuron plus rimisulfuron plus atrazine was used as a standard comparison with AE F130360-02. Across all locations, herbicide injury was minimal. Velvetleaf control was greater 85% with AE F130360-01 and AE F130360-02. The addition of atrazine, dicamba, dicamba plus diflufenzopyr, or mesotrione increased control of common lambsquaters, common waterhemp, and velvetleaf with AE F130360-01 and common waterhemp with AE F130360-02. Common lambsquarters, giant foxtail, and fall panicum control with AE F130360-02 was equivalent to the standard treatment of nicosulfuron plus rimisulfuron plus atrazine. Giant foxtail control with AE F130360-01 was equivalent to nicosulfuron. However, the addition of atrazine to either AE F130360-01 or AE F130360-02 antagonized giant foxtail control. AE F130360-01 and AE F130360-02 controlled common cocklebur better than either of the standards. AE F130360-01 and AE F130360-02 offers another option for postemergence grass control in corn, while providing equivalent or superior broadleaf control compared with the current standards.

EVALUATION OF ADJUVANTS WITH AE F130360 IN CORN. Richard J. Walker II* and Calvin G. Messersmith, Graduate Research Assistant and Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

AE F130360 is an experimental sulfonylurea herbicide being developed for grass and broadleaf weed control in corn. Field experiments were conducted in 2001 at Oakes, Mooreton, Crete and Casselton, ND, to evaluate adjuvants applied with AE F130360 for redroot pigweed, common lambsquarters, green and yellow foxtail, wild mustard and common cocklebur control. The adjuvants used were a petroleum-based crop oil concentrate, crop oil concentrate plus urea-ammonium nitrate fertilizer, ethylated seed oil, ethylated seed oil plus urea-ammonium nitrate fertilizer, two experimental adjuvants, methylated seed oil, methylated seed oil plus urea-ammonium nitrate fertilizer, and a basic blend adjuvant. AE F130360 was applied at 19 g ai/ha with a 1X (labeled) and 2X rate of each adjuvant and at 37 g/ha with the labeled adjuvant rate. Weed control was evaluated 7, 14, and 28 d after treatment.

Wild mustard control 28 days after treatment (DAT) by AE F130360 at Casselton was greater than 98% for all treatments that included an adjuvant, whereas common cocklebur control ranged from 28 to 73% and foxtail control ranged from 18 to 83%. Common lambsquarters control 28 DAT at Oakes ranged from 25 to 85%. Redroot pigweed control 28 DAT at Mooreton ranged from 80 to 94%. AE F130360 applied with methylated and ethylated seed oils either alone or in combination with urea-ammonium nitrate fertilizer provided the greatest weed control, but with crop oil concentrate provided the lowest level of weed control. Corn was not injured by AE F130360 with any of the treatments. Results of field experiments demonstrate the potential of AE F130360 for control of both grass and broadleaf weeds in corn, but proper adjuvant selection will be critical in determining the level of weed control that is achieved.

ATRAZINE ALTERNATIVES FOR WEED MANAGEMENT. Aaron L. Waltz, Fred W. Roeth, Alex R. Martin, Irvin L. Schleufer, and Jess J. Spotanski, Graduate Research Assistant, Professor, Professor, Technician, Technician, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, 68583-0915.

The herbicide atrazine is a popular and effective tool in weed management. However, atrazine use in areas with near-surface water tables and soils that readily leach is being scrutinized due to groundwater concerns. Due to this concern, there are currently region-specific restrictions on atrazine use. It is possible more stringent regulations may come in the future as well. Field studies were conducted at two different sites from 1997 through 2000 to identify possible alternatives to atrazine. The objective was to determine which herbicides or combinations of herbicides are equivalent to atrazine for weed control.

New and old chemistries were included as treatments, as well as atrazine to be used as the standard for direct comparisons. Herbicide application timings with PRE, POST, and sequential applications were included as well. The studies were conducted two years under conventional tillage and two years under a no-tillage system. There were some effective PRE and POST treatments, but the most effective treatments for weed management were those that included a sequential application of herbicides. These results indicate there are some possible weed management alternatives for atrazine, thus possibly reducing the amount of atrazine needed for acceptable weed control and lowering the risk of groundwater contamination.

PERSISTANCE AND EFFICACY OF FALL-APPLIED SIMAZINE AND ATRAZINE. Andrew T. Lee and William W. Witt, Graduate Research Assistant and Professor, Department of Agronomy, University of Kentucky, Lexington, KY 40546.

Applying triazines to soybean stubble in the fall has become popular among Kentucky herbicide applicators aiming to spread out their workload and control winter annual weeds. Controlling winter annual weeds before planting corn may provide many advantages including warmer spring soil temperatures, less crop drought stress, and less reliance on burn-down herbicides in no-till production systems. Controlling winter annual weeds also provides early spring cosmetic benefits that are of high interest to producers that cash-rent cropland. Field studies were conducted in November 2000 through October 2001 to determine herbicide persistence and efficacy from fall applied atrazine and simazine. A nine-treatment study, comprised of three fall herbicide options followed by three spring herbicide options, was replicated across three locations (Lexington, Princeton, and Bowling Green) in Kentucky. Atrazine at 1.7 kg/ha, simazine at 1.7 kg/ha, and no herbicide application were the fall herbicide options. Spring herbicide options included 1.3 kg/ha metolachlor + 1.7 kg/ha atrazine, 1.3 kg/ha metolachlor + 1.7 kg/ha atrazine + 1.1 kg/ha glyphosate, and no herbicide application. Soil samples were collected at 30 day intervals (January through May) to determine atrazine, simazine, and total triazine concentration. Yield data along with February, March, April, and May visual efficacy ratings for winter and summer annual weed control were used to compare differences among treatments ($P=0.05$). Surface soil temperatures were taken in three hour intervals during March and April.

Atrazine and simazine exhibited up to 95% control of henbit, but neither herbicide controlled or suppressed summer annual weed populations. Wild garlic control in February with atrazine was statistically greater than with simazine at the Princeton location. Wild garlic control ranged from 56% to 59% with atrazine, and 18% to 25% with simazine. No statistical differences of corn emergence, except for a decrease in the weedy check, were observed. The same pattern held true with corn seed yield. Yields ranged from 3,390 kg/ha to 11,200 kg/ha. Surface soil temperatures ranged from 1°C to 29°C. Daily fluctuation of surface soil temperature was higher where simazine was applied compared to where no herbicide was applied. January soil samples from plots treated only with fall-applied atrazine and simazine ranged from 0.6 to 1.0 ppm for atrazine, and 0.7 to 2.7 ppm for simazine. These numbers declined to ~ 0.02 ppm in May. Throughout the sampling period, simazine treatments contained about 2X the herbicide concentration in the soil over atrazine.

In conclusion, both fall applied simazine and atrazine were effective for henbit control. Henbit control translated into warmer surface soil temperature, but more variability during the diurnal cycle. Atrazine may offer better control of early season winter annuals such as wild garlic. Atrazine degraded more quickly than that of simazine under the conditions present from November 2000 to May 2001 in Kentucky.

MANAGEMENT OF ANNUAL RYEGRASS COVER CROP IN CORN AND SOYEAN. Darrin M. Dodds and Michael V. Hickman, Graduate Research Assistant and Adjunct Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Damage to soil structure and quality may be masked by improvements in the crop genetics or other inputs. Fall seeded cover crops designed to mimic long-term crop rotation while maintaining existing cash crop rotations may serve as a tool for soil quality improvements. Annual ryegrass was chosen on the basis of winter hardiness, cost (seed and seeding), and ease of planting into residues after burndown. Annual ryegrass forms a crown below the soil surface that complicates control. This prompted studies to determine effective control methods within existing rotation. Greenhouse research was conducted to determine the effect of annual ryegrass on soil structure and the efficacy of various herbicidal tank-mixes. Label and extension recommendations suggested the initial herbicides and use rates. The herbicides that performed best in the greenhouse were tested in the field. Field tests were conducted at the Purdue Agronomy Research Center in West Lafayette, IN, where annual ryegrass was seeded in mid-September at a rate of 39 kg/ha on a Chalmers silty clay loam soil. Experiments were performed to determine efficacy for burndown, pre-, and post-emerge control in no-till corn and soybeans. Ratings were taken visually to determine control (0-100, 0 = no control, 100 = complete necrosis). Weed counts were taken 6 weeks after application for all trials and also before application for post-emergence experiments. Glyphosate and various tank mixes thereof provided excellent control, while paraquat was unacceptable for burndown applications in corn and soybeans. Paraquat was unacceptable due to regrowth of the plant after application. S-metolachlor + atrazine provided adequate control pre-emergence in corn. Sulfentrazone gave good control in soybeans, however, a substantial stand loss of soybeans was observed. Nicosulfuron + rimsulfuron + atrazine gave the best control post-emergence in corn, while clethodim worked best later in the season in soybeans.

COMMERCIAL PERFORMANCE OF CARFENTRAZONE ON GRAIN SORGHUM. Robert S. Hooten, Terry W. Mize, and Gail G. Stratman, Market/Regulatory Support, Technical Team Manager, and Technical Support, FMC Corporation, Philadelphia, PA 19103.

Carfentrazone received a full federal label for use on sorghum late during the 2000 growing season. The first full year of commercial use was in 2001. Past studies had shown that carfentrazone was extremely effective in controlling redroot pigweed, velvetleaf, common lambsquarters, eastern black nightshade, and various morningglory species. In 2001, over 200,000 sorghum acres received a carfentrazone application at 0.008 lb ai/A to aid in controlling the listed broadleaf weeds. Crop symptomology was as expected and was rapidly outgrown causing no detrimental effects. Weed control was exceptional with little to no complaints on performance. The first year of commercial use confirmed that carfentrazone is an effective postemergence broadleaf herbicide that can be applied alone or in combination.

GRAIN SORGHUM RESPONSE TO TANK MIXES OF METSULFURON AND GROWTH REGULATOR HERBICIDES. Dave W. Brown, Kassim Al-Khatib, and David L. Regehr, Graduate Research Assistant, Associate Professor, and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506

Field and greenhouse experiments were conducted to evaluate the efficacy and safening of metsulfuron applied with dicamba, 2,4-D, clopyralid, and fluroxypyr with and without nonionic surfactant (NIS). Greenhouse data shows that 2,4-D and dicamba safened sorghum against injury. Whereas, fluroxypyr did not safen sorghum against injury. In the field study, sorghum injury was decreased when 2,4-D and dicamba was tank mixed with metsulfuron, whereas clopyralid and fluroxypyr caused little to no reduction in injury. Sorghum injury was greatest at 1 and 2 WAT, but plants recovered from injury at 4 WAT. Safening with 2,4-D and dicamba against metsulfuron injury did not result in a reduction in ivyleaf morningglory or velvetleaf control. Ivyleaf morningglory was controlled at 4 WAT by 95, 84, 59, and 91%; and velvetleaf was controlled by 88, 82, 78, and 95% when metsulfuron was tank mixed with 2,4-D, dicamba, clopyralid and fluroxypyr respectively. This study shows that 2,4-D, and dicamba safened metsulfuron to sorghum injury, while maintaining high weed control.

INFLUENCE OF SHADING, SEED SIZE AND GROWTH RATE ON CROP AND WEED RESPONSES TO NITROGEN. Matthew M. Harbur and Micheal D.K. Owen, Graduate Research Assistant and Professor, Department of Crop, Soil and Atmospheric Sciences, Iowa State Univ. Ames, IA 50011.

The incorporation of soil nitrogen manipulation into integrated weed management has been largely unsuccessful, in part, due to the failure to identify factors that potentially explain differences in nitrogen response between species. Corn, soybean and six weed species were grown in sand culture in order to determine the effect of shading, seed size and growth rate on nitrogen response. Plants were growth with and without shade, and fertilized daily with a complete nutrient solution that contained either 7.5 or 0.2 mM nitrogen. Dry weight and leaf area at 18 days after emergence decreased sharply in response to shade and low nitrogen availability. Dry weight and leaf area responses to shading and nitrogen availability were greater under high nitrogen and unshaded conditions, respectively. Proportional decreases in dry weight and leaf area were weakly correlated with seed weight, but were strongly correlated with relative growth rates, calculated from dry weight and leaf area, under optimal conditions. The absolute and proportional decreases in relative leaf growth rate were also strongly correlated with relative leaf growth rate under optimal conditions. Recognition of the role of shading and relative growth rate in N response may improve the prediction of the effect of nitrogen management on particular crop-weed competitions.

THE EFFECTS OF NITROGEN SUPPLY ON ROOT:SHOOT RATIO IN CORN AND VELVETLEAF. Kimberly D. Pavelka and John L. Lindquist, Graduate Research Assistant and Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE 68583-0817

Competition between crops and weeds can be better understood with knowledge of how plants partition their new biomass in response to a gradient of nutrient supply. This study was conducted in pots in the field to determine the fraction of biomass partitioned to the root versus the shoot in corn and velvetleaf over time in response to nitrogen. Pots measuring 28 cm in diameter and 60 cm deep were buried in holes in the ground and contained one plant of either corn or velvetleaf. Each plant received one of three nitrogen treatments: 0, 1 g, or 3 g of nitrogen applied as ammonium nitrate. Beginning one week after emergence, measurements of total above and belowground biomass were made once a week for ten weeks during the growing season. The root:shoot ratio decreased over time for both corn and velvetleaf as a result of normal plant growth and development, and the root:shoot ratio also decreased for both corn and velvetleaf as nitrogen supply increased. Root:shoot ratio differed between the two species for all stages of development and at all levels of nitrogen supply. Both corn and velvetleaf display plasticity in root:shoot ratio in response to nitrogen supply and the degree of plasticity in root:shoot ratio differs between species.

THE INFLUENCE OF TEMPERATURE AND SHADE ON EASTERN BLACK NIGHTSHADE AND HAIRY NIGHTSHADE GERMINATION AND GROWTH. Amy E. Guza, Adrienne M. Rich, Karen A. Renner, and Chad D. Lee, Undergraduate Research Assistant, Graduate Research Assistant, Academic Specialist, and Professor, Michigan State University, East Lansing, MI 48824.

Eastern black nightshade and hairy nightshade are two weed species in the *Solanaceae* family that reduce crop yield and quality in soybean, dry edible bean, and other crops. Eastern black nightshade and hairy nightshade are reported to be shade tolerant. Research was conducted to determine the optimum temperature regime for germination and the influence of shade on the emergence and growth of one population of each of these two nightshade species. Germination over a 14 day period was determined for five day:night temperature regimes: 20:10, 25:15, 25:25, 30:20, 35:25 C. To determine the influence of shade on eastern black nightshade and hairy nightshade emergence, seeds were placed at a 1 cm depth in a sandy loam soil and emergence measured over a 21 day period. Growth chambers were set at a 12 hour photoperiod, with a temperature regime of 30:20 C day:night temperature. Eastern black nightshade and hairy nightshade growth was measured for eight weeks in the greenhouse (16 hour photoperiod, 30:20 C day:night temperature) under 0, 30, 60 and 90% shade cloth. Germination of both nightshade species was greatest at 30:20 C. Shading had no influence on eastern black nightshade emergence but 90% shading reduced hairy nightshade emergence by 35%. Sixty percent shading decreased the leaf area index of eastern black nightshade and hairy nightshade by 68 and 73%, respectively, compared to the no-shade treatment 3 weeks after planting. Ninety percent shading decreased the leaf area index of eastern black nightshade and hairy nightshade by 68 and 87%, respectively. The length and width of the fourth leaf of eastern black nightshade was reduced by 23, 31, and 47% at 30, 60, and 90% shading, respectively, compared to the no-shade treatment when measured 6 weeks after planting. The length and width of the fourth leaf of hairy nightshade was reduced by 7, 32, and 56% at 30, 60, and 90% shading, respectively, compared to the no-shade treatment. This population of Eastern black nightshade appears to be more shade tolerant than hairy nightshade, suggesting that increasing crop density by planting narrow rows or increasing plant populations in the row may reduce the competitiveness of hairy nightshade more than that of eastern black nightshade.

RADIATION-USE EFFICIENCY OF BROADLEAF AND GRASS WEED SPECIES IN MONOCULTURE AND IN CORN. Greta G. Gramig and David E. Stoltenberg, Graduate Research Assistant and Associate Professor, Department of Agronomy, University of Wisconsin, Madison, WI, 53706.

Empirical crop-yield loss models based on weed density are typically unstable both spatially and temporally, because such models lack physiologically-based parameters that respond to environmental stochasticity. Mechanistic, physiologically-based models of crop-weed interactions offer the potential to increase accuracy and stability of crop-yield loss predictions, but these models can be inaccurate due to additive errors associated with large numbers of parameters. These problems may be addressed by focusing on physiologically-based parameters that are critical in determining outcomes of crop-weed competition. Photosynthesis is a major determinant of plant biomass production. As such, the quantity of radiation intercepted, and its utilization, may be one of these critical parameters. Therefore, our objective was to determine the radiation-use efficiency (RUE) of six weed species as an initial step toward characterizing crop-weed competition for light.

A field experiment was conducted in 2001 at the University of Wisconsin–Arlington Agricultural Research Station. Experimental design was a split-plot randomized complete block with three replications in 4- by 4-m plots. Community type (weed grown in monoculture or in corn) was the main plot factor and weed species was the subplot factor. Corn was planted at 79,000 seeds ha^{-1} in 76–cm wide rows on May 14 and weed seeds (giant ragweed, pigweed species, velvetleaf, large crabgrass, wild proso millet, and woolly cupgrass) were planted by hand on May 15. Target weed densities were established shortly after emergence by culling and transplanting seedlings. Water and nutrients were applied for optimal plant growth.

One corn plant and one to three weed plants per plot were randomly selected at regular intervals during the growing season, cut at the soil surface, divided into 30-cm height intervals, and measured to determine leaf area index (LAI) and shoot dry biomass. Measurements of daily mean air temperature and daily total solar radiation were obtained from a nearby weather station. Daily total shoot biomass accumulation based on growing degree days (GDD) was estimated from regression analysis. Intercepted photosynthetically active radiation (IPAR) was calculated using a Beer's Law relationship that describes IPAR in terms of LAI, and an extinction coefficient that measures the attenuation of light through a plant canopy as a function of leaf angle distribution. Daily IPAR was determined using linear and non-linear regression of GDD versus IPAR. The change in IPAR ($MJ\ m^{-2}s^{-1}$) was regressed against change in accumulated plant biomass ($g\ m^{-2}$) to determine RUE. Mean RUE values were tested for significance using the appropriate F-tests. Preliminary analysis suggests that RUE values for broadleaf weeds grown in monoculture were greater than those for grass weed species. This analysis also suggests that RUE values for weeds were less in corn than in monoculture; however, additional analysis is required to elucidate treatment effects.

LIGHT LEVEL INFLUENCES ON THE RELATIVE COMPETITIVENESS OF SHATTERCANE AND COMMON SUNFLOWER. Stephanie R. Deines, J. Anita Dille, David L. Regehr, and Scott Staggenborg, Graduate Research Assistant, Assistant Professor, Professor and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Shattercane and common sunflower are two dominant competitors in Kansas row crops. Through understanding their relative competitiveness, improved weed management decisions can be made using economic thresholds or decision support systems. Common sunflower has proven to be more competitive than shattercane in the field due to its ability to capture more light. Common sunflower is taller and has greater leaf area than shattercane. The objective of the study was to determine relative competitiveness of common sunflower and shattercane in response to two light levels by comparing the relative yield and aggressivity of each weed species. In the greenhouse a replacement series was set up in a split-split plot design replicated four times. Eight plants were established in plastic pots 15 cm in diameter filled with clay silt loam. Each pot consisted of a monoculture of shattercane, a monoculture of common sunflower, or one of three mixtures in 75:25, 50:50, and 25:75 planting ratios. Fifteen pots per replicate were exposed to one of two light levels (full sunlight and 25% sunlight). The twenty-five percent sunlight was obtained by placing the pots under a tent of horticulture cloth. Plants were grown in the greenhouse under sodium halide lights at a daily mean temperature of 22C with a 16h photoperiod. The experiment was repeated with the first and second experiments initiated October 9, 2000 and July 11, 2001, respectively. Pots were rotated within each replication every third day to eliminate any edge effect and insure even lighting. Water was supplied via daily sub-irrigation to eliminate any competition for water. Pots were fertilized weekly with 23-19-17 to minimize nutrient competition. Individual plant height, weight, leaf area, and leaf number were measured at 14, 28, and 35 days after planting (DAP). Relative yield (RY) was determined by dividing the yield of a species in a mixture by the yield of the same species in a monoculture. Aggressivity of shattercane was determined by subtracting the RY of common sunflower from the RY of shattercane.

Relative yields of shattercane at 28 DAP were greater than the expected relative yield when grown with common sunflower across experiment dates and light levels, suggesting that shattercane was more competitive than common sunflower. Height and leaf area of shattercane at 28 DAP was significantly greater than common sunflower across experiment dates and light levels. In full sunlight, shattercane was 58 and 55% taller than common sunflower in the 50:50 ratio for experiments one and two, respectively. In 25% sunlight, shattercane was 21 and 41% taller than common sunflower in the 50:50 ratio for experiments one and two, respectively. Likewise, in full sunlight, leaf area of shattercane was 72 and 79% greater, while in 25% sunlight, was 75 and 78% greater than common sunflower for experiments one and two, respectively. The aggressivity of shattercane was significantly greater than zero across experiment dates and light levels, signifying that shattercane has a greater ability to capture light than common sunflower early in the growing season.

SOIL MOISTURE AND CORN YIELD AS AFFECTED BY GLYPHOSATE APPLICATION TIMING AND ROW SPACING. Caleb D. Dalley, James J. Kells, and Karen A. Renner, Graduate Research Assistant, Professor, and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Glyphosate effectively controls annual weeds at a wide range of heights and growth stages. In glyphosate resistant crops, herbicide application can be delayed to a point where weed interference occurs resulting in yield losses. Weed competition for soil moisture may be an important factor early in the growing season to which yield losses may be attributed. Glyphosate resistant corn was planted at 79,000 seeds/ha in 38 and 76 cm rows at two locations (East Lansing and Clarksville) to study the effects of herbicide application timing and row spacing on corn yield and weed competition for soil moisture. Glyphosate was applied at 0.84 kg/ha with 2% ammonium sulfate when weeds reached 5, 10, 15, 23, and 30 cm in height. Weeds were effectively controlled at all treatment timings. Time domain reflectometry (TDR) access tubes were inserted into the soil to one meter in depth within the crop row to allow for soil moisture measurements. Soil moisture was measured weekly at five depths (0-18, 18-36, 36-54, 54-72, and 72-90 cm). At Clarksville, soil moisture was 2.4% less in weedy compared weed-free plots at the 0-18 cm depth 52 days after planting (DAP). At East Lansing, soil moisture at the 0-18 cm depth was reduced in weedy corn compared to weed-free corn by 2.7% at 63 DAP. Weed biomass was measured near the end of the growing season. Biomass of weeds emerging following glyphosate application was reduced as herbicide applications were delayed. Delaying glyphosate application until weeds reached 23 cm resulted in a 23 and 10% yield loss at East Lansing, and Clarksville, respectively. Yield losses also occurred when glyphosate was applied at the 5 cm weed height at both locations, possibly due to emergence of weeds following glyphosate application.

TIME OF DAY EFFECT ON GLYPHOSATE EFFICACY. Keith Mohr and Reid J. Smeda, Graduate Research Assistant and Assistant Professor, Agronomy Department, University of Missouri, Columbia, MO 65211.

Under some conditions, glyphosate efficacy has been reported to decrease when evening applications were made. Several studies have suggested diurnal leaf movements as a possible reason for reduced control. However, reduced control has also been observed on species that exhibit little to no diurnal leaf movement.

Greenhouse studies were conducted to determine the effect of glyphosate rate and velvetleaf leaf angle on time of day applications. Velvetleaf were grown in a 14 h photoperiod (starting at 06:00 h). On 4-leaf stage plants, 0.01 or 0.042 kg ae/ha glyphosate was applied; only 0.042 kg/ha glyphosate was used for the leaf angle study. Application time and corresponding leaf angle (in degrees) were 14:00 (-10), 17:00 (-10), 18:30 (-30), 19:15 (-60), and 20:00 h (-80). Leaf angle was measured as follows: 0 degrees = leaf parallel to ground, -90 degrees = leaf perpendicular to ground. Pipe cleaners were used in the leaf angle study to mechanically manipulate leaf angle. In one series of treatments, leaf angle was manipulated to correspond with each angle above and all treatments were sprayed at 14:00 h. In another series, leaf angle was held constant at -10 degrees and sprayed at the above stated times. In the final series of treatments, leaf angle was not manipulated, and herbicide applications were sprayed at each of the above times.

Plant biomass increased as glyphosate applications were delayed toward evening regardless of glyphosate rate or leaf angle. At 0.01 and 0.042 kg/ha glyphosate, biomass increased over 25 and 75%, respectively, between 14:00 and 20:00 h applications. In the leaf angle study, leaf angle alone accounted for 82% of the differences in efficacy compared to the control. When leaf angle was held constant, application time of day accounted for 17% of the difference in efficacy compared to the control. These data indicate that the time of day effect is not overcome by glyphosate rate and that leaf angle results in the greatest decline in glyphosate efficacy. Leaf angle alone, however, does not completely account for reduced glyphosate efficacy, suggesting that some physiological process(es) may be involved.

WIND SPEED AFFECTS WEED AND CORN GROWTH PARAMETERS. Michael J. Moechnig*, David E. Stoltenberg, Chris M. Boerboom, and John M. Norman, Graduate Research Assistant, Associate Professors, Department of Agronomy, and Professor, Department of Soil Science, University of Wisconsin, Madison, WI 53706.

Plant shoot height and leaf area development is an important aspect of competition for light in multiple weed species-corn communities. Previous research has indicated that the plasticity of weed shoot growth may be due primarily to the quality and quantity of intercepted light, but other factors can also affect carbon allocation to leaves and stems. Our objective was to determine the effect of wind speed on shoot growth of common lambsquarters, giant foxtail, and corn.

Greenhouse experiments were conducted in which common lambsquarters, giant foxtail, or corn plants were grown in either a high-wind speed tunnel (2.8 m s^{-1}) or a low-wind speed tunnel (0.5 m s^{-1}). Wind speeds were maintained for 18 h d^{-1} from 1 h before until 1 h after exposure to light. The daily photoperiod was 16 h at a quantum flux density of approximately 400 μmols m^{-2} s^{-1}. Ambient air temperature and humidity were similar between wind environments. In each experiment, 24 plants of one species were grown individually in containers placed in close proximity within each wind tunnel. Shoot height of each plant was measured weekly. Four plants per tunnel were selected randomly each week for destructive measurement of leaf area, leaf biomass, and stem biomass. Experiments were terminated when plants were between 40 and 50 cm in height. Data were used to develop a growth model for each species based on functions that described leaf partitioning coefficients, specific leaf area, stem partitioning coefficients, specific stem length (i.e. shoot height per unit of stem biomass), and light use efficiency.

Common lambsquarters specific stem length was greater at low wind than high wind speed. However, wind speed did not affect common lambsquarters total shoot biomass or other measured parameters. In contrast, giant foxtail and corn specific stem lengths were not affected by wind speed, but total shoot biomass and light use efficiency of each species was greater at low wind than high wind speed. Therefore, exposure to high wind speed differentially affected shoot growth of these species, suggesting that exposure to higher wind speeds in a corn community may confer a competitive advantage to common lambsquarters relative to giant foxtail.

WEED PHENOLOGICAL VARIATION IN REALTION TO WEATHER: AN ANALYSIS OF 82 WISCONSIN WEEDS OVER FOUR YEARS. Ed Luschei and Jerry Doll, Professors, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

A diverse collection of annual, biennial and perennial weeds were monitored for four years at a single site at the Arlington Agricultural Research Station in south-central Wisconsin. We report on the relative and absolute consistency of first-emergence/growth and first-flower times across species and within categorical groups (e.g. life-cycle type, chronological groups, physiological groups C3/C4). We examine the extent to which yearly deviations from means correlate with deviations in thermal time calculated across a range of base temperatures. For specific weeds, we correlate the 50% emergence time predicted using WEEDCAST 2.0 with the observed date of first emergence. We also contrast results with other existing historical data from the Leopold farm in south central Wisconsin and Wisconsin Phenological Society. Ultimately we address the question: how much information is contained in the recording of a phenological observation of a species ‘X’ about (1) contemporaneous and, (2) future phenological events in sets of other species.

SPATIAL RELATIONSHIP OF ANNUAL WEED POPULATIONS TO TOPOGRAPHY. Nicholas N. Schneider, Gregg A. Johnson, Beverly R. Durgan, and Jay C. Bell, Graduate Research Assistant, Associate Professor, Professor, and Associate Professor, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108.

The heterogeneous nature of weed distributions within agricultural fields has been demonstrated in numerous studies. Much of the research exploring weed spatial heterogeneity has focused on the interaction between weed species and soil properties. Soil physical and chemical properties are also heterogeneous, but not random. Soil morphology is the result of five soil forming factors, of which, landscape relief contributes to predictable soil changes in the Des Moines lobe till of southern Minnesota and northern Iowa.

A field experiment was conducted to observe weed species richness, weed seedling density, and weed growth across a catena. Research was conducted in a 16 ha soybean field at the University of Minnesota Southern Research and Outreach Center's Agroecology Research Farm. Weed population dynamics data are presented from ten research sites in 2000 and eight research sites in 2001. Research site locations were selected based on hillslope position, aspect, slope, and soil taxonomy. There were two summit sites ('S' sites), five backslope sites ('B' sites), and three toeslope sites ('T' sites) in 2000. Sites serve as treatments. Due to increased spring soil moisture in 2001, two toeslope sites were excluded from the study and field research began five weeks later.

In 2000, toeslope sites contained 18 to 22 weed species; meanwhile, backslope and footslope sites contained 10 to 13 weed species. In 2001, all sites contained between nine and twelve weed species.

Weed seedling density data is presented for annual grasses, common ragweed, and common lambsquarters. Sites were compared using analysis of variance contrast statements at each sampling date. Annual grass seedling densities in 2000 were greatest at the toeslope sites with peak emergence of greater than 1000 seedlings m^{-2}. Summit and backslope sites contained between 10 and 51 annual grass seedlings m^{-2} with site densities B5>B4=B3=B1=S2=S1>B3. In 2001, the toeslope site had a greater annual grass seedling density than all backslope sites; meanwhile, summit sites had an intermediate density and were similar to both the toeslope and backslope sites. Common lambsquarters had an opposite seedling density trend in 2000 with S1>S2=B4>remaining backslope and toeslope sites. Common lambsquarters spatial relationship changed considerably in 2001 with sites T1, B1, B3, B4, and S2 having the greatest density.

Weed height data showed both spatial and temporal variability. Height trends were temporally unstable as toeslope sites often had greater heights early in the growing season but shorter heights by mid-summer. These results demonstrate annual weed species diversity, seedling density, and height are different across a Des Moines lobe till catena.

DETERMINING SOYBEAN ROW SPACING EFFECTS ON WEED COMPETITIVE ABILITIES FOR WEEDSOFT. Ryan D. Lins and Chris M. Boerboom, Graduate Research Assistant and Associate Professor, Department of Agronomy, University of Wisconsin, Madison WI 53706.

The effect of soybean row spacing on weed competitive ability should be incorporated into bioeconomic weed management models to improve the accuracy of their yield loss estimates. To determine the magnitude that soybean row spacing affects weed competitive abilities, data was analyzed from five field experiments that were used to validate WeedSOFT. The five experiments were established with one in East Lansing, MI, two in Columbia, MO, one in Arlington, WI, and one in Lancaster, WI during 2000 and 2001. Experiments were arranged in a randomized complete block, split plot design with four replications where the main plots were soybean row spacing. The experiments in Michigan and Wisconsin compared 19- and 76-cm row spacings, while the experiments in Missouri compared 38- and 76-cm row spacings. Herbicide treatments used in individual experiments were site specific and chosen from WeedSOFT yield loss predictions so that the treatments would provide a range of yield loss in each study. Weed free and nontreated controls were also included in each study. Pre-harvest weed biomass and soybean yield were measured in each study. A ratio of narrow row (19 or 38 cm) weed biomass to wide row (76 cm) weed biomass was used to determine the extent that row spacing affected weed competitive abilities for each study. To determine the direct effect of soybean row spacing on weed competitive abilities, the total pre-harvest weed biomass for treatments that were applied to both row spacings were compared. Comparing soybean yields as a percentage of the weed free yield tested the indirect effect of row spacing on weed competitive ability.

The Arlington, WI and both Columbia, MO studies had less weed biomass in the narrow row spacing than in the wide row spacing at $P = 0.1$. The ratio of mean weed biomass in narrow row soybean to wide row soybean was 0.78, 0.63, and 0.87 for Arlington, WI and Columbia, MO in 2000 and 2001, respectively. At Lancaster, WI, the weed biomass in 19-cm rows averaged 81% of the weed biomass in the 76-cm rows, but was not statistically significant. In four of the five studies, narrow row soybean had 2.2 to 8.6 % less yield loss than wide row soybean when expressed as a percent of the weed free yield, but only the Columbia, MO study in 2001 had a significant difference. This data analysis suggests that narrow row soybean can reduce the competitive ability of weeds when compared to wide row soybean. However, the variation in the data of these studies made it difficult to measure differences between row spacings. Further research is needed to more accurately quantify the magnitude of the row spacing effect.

INFLUENCE OF OVERSEEDED FORAGE GRASSES ON SOYBEAN YIELD AND WINTER ANNUAL WEED SUPPRESSION. Satish K. Guttikonda, Kelly A. Nelson and William G. Johnson, Graduate Research Assistant, Assistant Professor and Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO, 65211.

Soybean fields often remain fallow throughout the winter months in the Midwest and become infested with winter annual weeds. Diversified crop and livestock producers may utilize winter annual forages for winter annual weed suppression and utilize fallow soybean ground for winter livestock grazing. Experiments were conducted at Novelty, MO to evaluate winter rye (*Secale cereale* L.) and annual ryegrass (*Lolium multiflorum* L.) seeding timings in established soybean to determine the optimum seeding date and the influence of winter annual forage grasses on winter annual weed suppression and soybean yield. Winter annual forages were seeded at R6, R6.5, R7, and after soybean were harvested. Winter annual forage seeding did not reduce soybean grain yield. Light interception decreased as soybean matured. Winter rye stand was not affected by seeding timing; however, annual ryegrass stand was greater at the R6 and R6.5 seeding dates compared with a post harvest seeding. Early winter rye and annual ryegrass seeding dates provided the greater forage yield than post harvest planting. Winter rye seeded at R6 reduced biomass of winter annual grass 41% and broadleaf weeds 48%, while post harvest seeding reduced the grass weed biomass 39% and broadleaf biomass 38% compared to plots without forage grasses. Annual ryegrass seeded at R6 reduced the biomass of grasses 17% and broadleaf weeds 3%, while post harvest seeding reduced biomass of the winter annual grasses 18%, but did not reduce biomass of broadleaf weeds. Winter rye provided greater winter annual weed suppression than annual ryegrass. Overseeded winter annual forage grasses may provide economic benefits for farmers as well as winter annual weed suppression.

Nomenclature: rye, *Secale cereale* L., annual ryegrass, *Lolium multiflorum* L.

GENETICS OF ALS RESISTANCE IN COMMON SUNFLOWER (*HELIANTHUS ANNUUS*). Anthony D. White and Micheal D. K. Owen, Department of Agronomy, Iowa State University, Ames, IA 50011-1010.

A common sunflower population from Howard, South Dakota was previously determined to be cross resistant to imazethapyr and chlorimuron. Experiments were designed to better understand the genetic characteristics of ALS resistance in the Howard common sunflower and to evaluate the potential of introgression into other *Helianthus* populations. Primer pairs were designed and synthesized to amplify the entire ALS gene (Regions A and B) in all of the *Helianthus* biotypes. Unfortunately, the forward primer at the 5’ end (nucleotide position 220) and the reverse primer at the 3’ end (nucleotide position 1980) did not amplify any of the biotypes, due to degeneracy in the primer sequence. Therefore, approximately 100 bases at each the 5’ and 3’ end of the ALS gene in the *Helianthus sp*. evaluated were not amplified. Approximately 529 amino acids were sequenced from the ALS gene in common sunflower and Jerusalem artichoke (*Helianthus tuberosus*). An alanine to valine substitution was observed at amino acid position 204. Previously documented mutations at this location indicated it played a pivotal role in conferring resistance to one or more ALS inhibitor herbicides. The detection of an amino acid sequence frame shift between positions 436 and 441 suggested that at least two copies of the ALS gene exist in the Howard common sunflower population. The shift was not seen in Jerusalem artichoke and indicated that either additional gene copies were not PCR amplified, or only one copy of ALS was present in the genome. The existence of upstream and downstream polymorphisms from the sequenced regions remains unknown since the entire gene was not sequenced. Segregation of progeny from R-S hybrids indicated ALS resistance in the Howard common sunflower population was likely due to a semi-dominant gene.

ALS MUTATIONS CONFERRING HERBICIDE RESISTANCE IN WATERHEMP. William L. Patzoldt and Patrick J. Tranel, Graduate Research Assistant and Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

In a recent survey of herbicide response variability among Illinois common and tall waterhemp populations, over 70% were found to have at least one individual with a resistant response following treatment with an imadazolinone (IMI) or sulfonylurea (SU) herbicide, both of which inhibit acetolactate synthase (ALS). Broad cross-resistance to ALS-inhibiting herbicides in common waterhemp has previously been found to be due to a tryptophan to leucine substitution at position 574 (W574L) of ALS. In several waterhemp populations within the survey that were resistant to both IMI and SU herbicides, we screened for this mutation by PCR amplification of *ALS* followed by MfeI restriction endonuclease digestion. Results revealed that the W574L substitution of ALS was responsible for resistance.

Several waterhemp populations were observed to have differential responses between IMI and SU herbicides. Further screening was performed on two populations in which plants were observed to be resistant to an application of imazethapyr, but sensitive to thifensulfuron. Imazethapyr-specific resistance was determined on greenhouse-grown waterhemp plants by utilizing a leaf disc expansion assay. This approach allowed for rapid, accurate, and non-destructive determination of imazethapyr resistance. Fragments of *ALS* were sequenced, and inferred amino acid sequences compared among resistant and sensitive plants from each population. One waterhemp population contained a serine to asparagine substitution at amino acid position 653 (S653N), and the other population contained a serine to threonine substitution at position 653 (S653T). These results were consistent with previous research with other plant species, in which a mutation at position 653 of ALS confers resistance to imadazolinone herbicides. PCR-based, allele-specific primers were developed to identify waterhemp *ALS* alleles that contained either the S653N or S653T substitutions. Plants were selected based on allele-specific primer data, and used in the development of homozygous resistant and sensitive waterhemp populations for use in *in vitro* ALS activity assays.

CROSS-RESISTANCE AND DOSE RESPONSE OF SHATTERCANE TO ALS-HERBICIDES.
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The continuous use of ALS-herbicides in Nebraska in the 1990's, led to the first reported appearance of ALS-resistant shattercane. In 2000, in Fairfield County, Ohio, a shattercane population persisted in a field that had received a primisulfuron plus or minus nicosulfuron application in ten of the previous eleven growing seasons. This suspected ALS-resistant population was sampled, along with a known susceptible population in Perry County, Ohio. A third population with unknown susceptibility was sampled in Madison County, Ohio.

Two greenhouse studies were conducted in 2001. The first study was designed to confirm the presence or absence of ALS-resistance and cross-resistance in the three populations. The objective of the second study was to determine the whole plant dose response of a resistant and susceptible population, as determined by the first study.

In the first study, nicosulfuron, primisulfuron and imazethapyr were each applied postemergence at a 2 times the recommended label rate (70, 80 and 140 g ai/ha, respectively) to each of the three populations. Herbicides were applied to V4-stage shattercane with an average height of 23 cm. Visual control ratings were taken 14 days after treatment. Results confirmed that the Fairfield County population was resistant to the three herbicides, indicating cross-resistance. The Perry County and Madison County populations proved to be susceptible to the three herbicides.

In the second study, the Fairfield County (R) and the Perry County (S) populations were used to evaluate the dose response of nicosulfuron, primisulfuron, and imazethapyr applied to 25 cm tall shattercane at the V6 stage. Herbicide doses ranged from 0.001 to 1000 times the recommended label rate. Visual evaluations and dry weights were recorded and the means fit to a logistic dose-response model to calculate GR_{50} values. For imazethapyr, the GR_{50} for the R-population was 26,176 g ai/ha and for the S-population was <0.07 g ai/ha. The nicosulfuron GR_{50} for the R-population was $>35,000$ g ai/ha and for the S-population was 0.23 g ai/ha. The primisulfuron GR_{50} was determined to be $>40,000$ g/ha for the R-population and <0.04 g ai/ha for the S-population. Therefore, the resistance ratios for imazethapyr, nicosulfuron and primisulfuron were approximately 374,000, 152,000 and $>1,000,000$ respectively.

These studies confirm the existence of ALS-cross-resistant shattercane in Ohio. The high levels of cross-resistance observed in the resistant population suggest there may be one or more alterations in the target site (ALS) that confers herbicide resistance. This high level of resistance suggests the presence of an insensitive ALS-enzyme site.

POTENTIAL BASIS OF RIGID RYEGRASS RESISTANCE TO GLYPHOSATE. Marulak Simarmata, Donald Penner, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI and John E. Kaufmann, 48824; Monsanto Company, Okemos, MI.

Past research has not elucidated the basis for the observed glyphosate resistance of a selection of rigid ryegrass from California. The objectives of this study were to examine differences in foliar absorption of glyphosate, distribution in the plant, absorption by isolated chloroplasts, and finally, accumulation of glyphosate in vivo in the chloroplast of sensitive and resistant plants. Foliar absorption and distribution of ^{14}C-glyphosate did not differ 1 to 3 days after treatment between the sensitive and resistant biotypes. Chloroplasts were isolated from young fully expanded leaves. Their integrity was verified with a confocal microscope. Absorption of ^{14}C-glyphosate by the isolated chloroplasts did not differ between the sensitive and resistant biotypes. Following foliar application of ^{14}C-glyphosate chloroplasts were isolated from treated leaves from both biotypes. Accumulation of ^{14}C-glyphosate did not differ between the two biotypes. Assay of the EPSP synthase in the two biotypes are anticipated.

EXPLORING GLYPHOSATE ACTION WITH DNA MICROARRAYS. Patrick J. Tranel, William L. Patzoldt, Anupama Khanna, Robin T. Shealy, and Lila O. Vodkin, Assistant Professor, Graduate Research Assistant, Postdoctoral Research Associate, Research Specialist, and Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Glyphosate inhibits 5-enopyruvylshikimate-3-phospate synthase (EPSPS), thereby blocking the production of aromatic amino acids. That EPSPS is glyphosate's primary site of action is confirmed by the fact that transgenic plants with a glyphosate-insensitive EPSPS are resistant to the herbicide. Nevertheless, the exact sequence of events by which glyphosate causes plant death is not known.

The use of DNA microarrays is a powerful new approach to simultaneously monitor the expression of thousands of genes. Applications of this technology to weed science could provide new insights into herbicide physiology. Previous research has resulted in the production of DNA microarrays containing soybean gene sequences. We have been using these microarrays to investigate glyphosate activity in soybean. Additionally, this approach will be used to investigate potential secondary effects of glyphosate in soybean having genetically engineered glyphosate resistance.

Conventional (glyphosate-sensitive) soybean plants were grown in growth chambers and treated at the V3 stage. Treatments were either a commercial formulation of glyphosate (1 kg ae/ha) or a corresponding rate of the formulation minus glyphosate, and were applied with a moving-nozzle spray chamber. Just prior to application, and at 1, 6, 12, 24, and 48 hours after application, six plants from each treatment were harvested. RNA was extracted separately from young leaves, old leaves, and roots from pooled plants within each treatment/time combination, and used to make dye-labeled cDNA probes. Two dyes having different fluorescence emission properties were used so that "plus glyphosate" cDNA probes could be distinguished from "minus glyphosate" cDNA probes. Labeled cDNAs from the different treatments (plus/minus glyphosate) but from the same tissue type and harvest time were mixed and hybridized to microarrays containing DNA fragments from over 9000 soybean genes. Relative signal intensities for each gene on the microarrays were quantified by scanning the hybridized array at the appropriate excitation and detection wavelengths for each dye.

Glyphosate treatment rapidly altered gene expression profiles. Within one hour after treatment, approximately 2% of the genes analyzed differed in abundance by 2.5-fold or more in young leaves between plus/minus glyphosate treatments. Some genes in young leaves differed by 10-fold or more in abundance between the two treatments after one hour. The number of differentially expressed genes increased at subsequent post-treatment times. Of the differentially expressed genes in young leaves, the majority were more abundant in plus glyphosate relative to minus glyphosate plants, particular at the early time points, before whole-plant symptoms were evident.

Reliability of the microarray data was evaluated by the inclusion of some genes at multiple locations on the microarray. For example, a gene that encoded the precursor to the small subunit of ribulose-1,5-bisphosphate carboxylase was at eight locations on the microarray. Combined across these locations for one particular tissue/time point, this gene was repressed 4.3-fold after glyphosate treatment, with a standard deviation of 0.2-fold. The similarity of relative signal intensities of multiple spots of an identical gene confirmed the reliability of the data.

EFFICACY, ABSORPTION, AND TRANSLOCATION OF GLYPHOSATE, GLUFOSINATE, AND IMAZETHAPYR ON SELECTED WEED SPECIES. Neal E. Hoss, Kassim Al-Khatib, Dallas E. Peterson, and Thomas M. Loughin, Graduate Research Assistant, Associate Professor, Professor, and Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS, 66506.

Experiments were conducted to determine the efficacy, absorption and translocation of glyphosate, glufosinate, and imazethapyr on selected weed species. In the greenhouse, glyphosate, glufosinate, or imazethapyr were applied at 0.25, 0.5 and 1X of the use rates of 1121, 410, and 70 g ha^{-1}, respectively, on 10- to 15-cm black nightshade, common waterhemp, eastern black nightshade, field bindweed, giant ragweed, ivyleaf morningglory, prairie cupgrass, velvetleaf, and yellow nutsedge. In general, visible injury increased as herbicide rates increased. Glyphosate applied at the 1X rate caused injury greater than or similar to injury from the 1X rate of glufosinate or imazethapyr on black nightshade, common waterhemp, eastern black nightshade, field bindweed, giant ragweed, prairie cupgrass, and velvetleaf. The 1X rate of glufosinate injured ivyleaf morningglory and yellow nutsedge more than the 1X rate of glyphosate or imazethapyr. Under field conditions, glyphosate applied at the 1X rate caused the greatest injury of common waterhemp, prairie cupgrass and velvetleaf across plant growth stages of 8, 15, and 30 cm. Giant ragweed and ivyleaf morningglory injury was more dependent on growth stage with the 15 and 30 cm growth stages more susceptible to glyphosate than to glufosinate or imazethapyr. Differential response of these weed species may be due to differences in herbicide translocation. Glyphosate was translocated more in both giant ragweed and ivyleaf morningglory and these species were injured more by glyphosate than by glufosinate or imazethapyr at the larger growth stages.

DIFFERENCES IN EFFICACY OF GLYPHOSATE FORMULATIONS ON FOUR WEED SPECIES.
Donald Penner and Jan Michael, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Glyphosate formulations may differ with respect to the salt or counter ion, adjuvant present, and percent of active ingredient. Efficacy of adjuvants may be weed and herbicide specific. A study was initiated to determine the effect of the adjuvants, both in the product and tank mixed, and water hardness on the efficacy of three glyphosate formulations on four weed species. These formulations differed with respect to the glyphosate counter ion. The formulations evaluated in greenhouse studies were Roundup Ultramax®, Touchdown IQ®, and Touchdown V® applied at 0.28, 0.42, and 0.627 kg ae/ha in deionized and tap water to velvetleaf, prickly sida, barnyardgrass, and large crabgrass. Plant injury was evaluated 7, 10, 14, and 21 days after treatment. At the 0.42 kg ae/ha application rate regardless of water hardness or weed species, the Touchdown IQ formulation was consistently less effective than the other two formulations. Very often this difference in performance was also evident where diammonium sulfate had been included as an adjuvant. The addition of 0.5% diammonium sulfate plus 0.25% nonionic surfactant to the Touchdown IQ application was markedly less effective than adding 2% diammonium sulfate.

INFLUENCE OF FALL HERBICIDE TREATMENT ON THE SEASONAL CHANGES IN CARBOHYDRATES IN THE ROOTS OF CANADA THISTLE. Robert G. Wilson, Professor, Department of Agronomy and Horticulture, University of Nebraska, Scottsbluff, NE 69361.

Field experiments were conducted near Scottsbluff, NE from 1999 to 2001 to examine the changes in glucose, fructose, sucrose, and fructans in the roots of Canada thistle following fall applications of dicamba. Plant roots were exhumed from the soil and analyzed with high-performance anion exchange chromatography. Canada thistle shoot density was measured 7 mo following treatment to determine herbicide effectiveness. Dicamba applied at 0.56 kg/ha 4 to 11 d before the first fall frost (-2C) was not as effective in controlling Canada thistle as treatments made 1 to 10 d after the first frost. Application of dicamba after the first frost resulted in a decrease in low- to mid-degree of polymerization fructans and increase in fructose in the roots of Canada thistle 30 d after treatment. Increases in Canada thistle control could be correlated with decreases in fructans and increases in fructose in plant roots. In a similar experiment dicamba was applied at 0.28, 0.56, and 1.12 kg/ha and 2,4-D at 0.56, 1.12, and 2.24 kg/ha 4 d before the first fall frost. Dicamba was more effective in controlling Canada thistle 7 mo following treatment than 2,4-D and control with both herbicides increased as rate increased. Increases in Canada thistle control with increases in dicamba could be correlated with decreases in fructans and increases in fructose and glucose in plant roots. Increases in 2,4-D caused much smaller decreases in fructans and increases in fructose and glucose in the roots of Canada thistle than dicamba.

SAFENING OF ISOXAFLUTOLE IN CORN. Eric A. Nelson and Donald Penner, Graduate Research Assistant and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Greenhouse experiments were conducted to evaluate the potential for safening isoxaflutole in corn (*Zea mays* L.). Isoxaflutole, a member of the isoxazole class of herbicides, is used for preemergence control of important grass and broadleaf weed species in corn. Isoxaflutole usage rates range from 75 to 140 g ai/ha. Degradation of isoxaflutole occurs rapidly in tolerant species such as corn. The rapid metabolism of isoxaflutole is the basis for selectivity. In addition to many important weed species having sensitivity to isoxaflutole, some lines of corn are less tolerant than others. Previous research indicated that the addition of a mixed function oxidase inducer to the isoxaflutole spray mixture decreased injury to the less tolerant corn lines. However, the safening effect in corn observed under greenhouse conditions did not manifest itself under field conditions. The objectives of this study were to evaluate the leaching of the safener R-29148 and isoxaflutole to determine if the two compounds were moving at different rates through the soil profile, and if the two were moving at different rates, attempt to retard and synchronize their movement. A trial was conducted to determine the appropriate amount of water to add to the columns as simulated precipitation. Polyvinyl chloride (PVC) pipes 38 cm tall with a 10 cm diameter were filled with Spinks loamy sand soil to a depth of 31 cm. The soil columns were treated with isoxaflutole at a rate of 630 g ai/ha. The volumes of water evaluated were 155, 310, and 620 ml or 1.9, 3.8, and 7.6 cm simulated precipitation respectively. The columns were split longitudinally, giant foxtail (*Setaria faberi* Herrm.) was planted on one half of the column, and Great Lakes Hybrids corn Inbred #18 (I-18) was planted on the other half. The movement of isoxaflutole can be measured by the visible effect on the weed assay species and the movement of the safener can be measured by the visible effect on the crop assay species. The previously mentioned volumes of water created ratio of the front (R_f) values of 0.2, 0.38, and 0.62 respectively. Simulated precipitation of 7.6 cm was chosen to evaluate the safening effect. R-29148 was added to the columns at two rates with isoxaflutole and these treatments were compared to isoxaflutole alone.

FORAMSULFURON AND ISOXADIFEN-ETHYL: ABSORPTION, TRANSLOCATION AND METABOLISM. Ken Pallett*, Ponnan Veerasekaran, Mandy Crudace, Helmut Köcher and Brent Collins. *Head of Herbicide Biology, Aventis CropScience, GmbH, Industriepark Hoechst, D-65926, Frankfurt am Main, Germany.

Foramsulfuron (AE F130360; 1-(4,6-dimethoxypyrimidin-2-yl)-3-(2-dimethylcarbamoyl-5-formamidophenylsulfonyl)urea) is a novel sulfonylurea herbicide for post-emergence use in corn. As with other sulfonylurea herbicides, it is a very potent inhibitor of the enzyme acetolactate synthase (ALS). Foramsulfuron is effective against major grass weed species, as well as some broad-leaved weeds. It is applied with the new Aventis CropScience safener, isoxadifen-ethyl (AE F122006; ethyl 5,5-diphenyl-2-isoxazoline-3-carboxylate), which ensures the highest level of selectivity without compromising product effectiveness.

The foliar uptake of foramsulfuron is substantially enhanced when applied with adjuvants such as esterified seed oil and over 80% penetration is achieved with 1% Hasten 72 hours after application. Foramsulfuron shows only limited translocation, with less than 5% of ^{14}C-activity translocated out of treated leaves. However, the potent inhibition of ALS ($p IC_{50}$=7.5) presumably contributes to the effective control of susceptible weed species. Using an excised leaf system to monitor metabolism of ^{14}C-foramsulfuron a correlation has been established between sensitivity to the herbicide and its metabolic half-life. In tolerant corn hybrids, such as P3394 the half-life of foramsulfuron is 4.2 hours, whereas in a more susceptible hybrid, Lorenzo it is 13.9 hours and exceeds 40 hours in susceptible weed species. Foramsulfuron is detoxified in corn via three initial metabolic routes, a hydrolytic cleavage of the sulfonylurea bridge; a deformylation of amino group; and oxidative metabolism of the dimethoxy-pyrimidyl ring.

Foliar uptake of the safener in a 1:1 mix with foramsulfuron and 1% Hasten, exceeds 90% after 24 hours. It is more systemic than foramsulfuron. The safener has no impact on the rate of foliar penetration of foramsulfuron nor on the translocation of ^{14}C- activity from treated leaves. In the excised leaf system isoxadifen-ethyl enhances the degradation of foramsulfuron in corn. In a comparative whole plant study, in which the second leaf of 3-leaf corn plants was treated with ^{14}C-foramsulfuron in the presence and absence of the safener, there was a reduction in the proportion of ^{14}C-activity remaining as parent sulfonylurea in both Lorenzo and P3394 three days after treatment. In the absence of safener with Lorenzo 29% of ^{14}C-activity in treated leaves was parent compared to 14% in the presence of isoxadifen-ethyl. The proportion of translocated foramsulfuron was 23% and 10% in the absence and presence of safener respectively. In P3394 the proportions of ^{14}C-activity remaining as foramsulfuron reduced from 16 to 13% in treated leaves and from 13 to 5% in translocated activity in the presence of isoxadifen-ethyl.

In conclusion, foramsulfuron is extensively metabolised in corn but not in susceptible weed species. The addition of the safener enhances the selectivity by increasing the detoxification of foramsulfuron in corn.

USING ARABIDOPSIS AS A MODEL TO STUDY THE INDUCTION OF HERBICIDE DETOXIFICATION SYSTEMS BY SAFENERS. Ben P. DeRidder and Peter B. Goldsbrough, Graduate Research Assistant and Professor, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907.

Herbicide selectivity is central to the success of chemical weed control in agriculture. For years, herbicide safeners have been used to enhance the selectivity of weed control in cereal crops. Safeners act predominantly by inducing herbicide detoxifying enzymes such as glutathione S-transferases (GSTs). Safener-induced GSTs can conjugate a herbicide to glutathione (GSH), thereby providing tolerance to that compound. However, little is known about how safeners induce detoxification systems in plants. In this study we have evaluated Arabidopsis as a model to study safener response mechanisms in higher plants. Treatment of Arabidopsis seedlings with safeners resulted in increased GST activity against both the model substrate CDNB and herbicide substrates. GSTs from safener-treated seedlings were purified by GSH-affinity chromatography and displayed by 2-D SDS-PAGE. A 25.6 kD protein that was induced by a number of safeners was identified by MS analysis of trypsin-digest fragments as a novel GST, *At*GSTU19. When expressed in *E. coli*, *At*GSTU19 has high CDNB activity and is able to conjugate several chloroacetamide herbicides at rates similar to those reported for GSTs in sorghum and maize. Based on its high level of activity with CDNB and herbicides, and its abundance in protein extracts, it is likely that *At*GSTU19 is the major contributor to the increase in GST activity following safener treatment. RNA blot and immnoblot analyses confirmed that *AtGSTU19* transcript levels and *At*GSTU19 protein levels, respectively, increase in response to safeners that are utilized in cereal crops to increase chloroacetamide herbicide selectivity. RNA blot analysis using cDNA probes representing other Arabidopsis GSTs showed that expression of a number of GSTs is upregulated in response to safeners. However, all safeners do not induce the same profile of GSTs in Arabidopsis, suggesting that multiple pathways are involved in the regulation of GST expression by safeners. Analysis of transgenic Arabidopsis lines overexpressing *At*GSTU19 as well as reporter gene constructs driven by the *AtGSTU19* promoter will add to our understanding of the regulation and function of safener-induced GSTs in plants.

5-KETO CLOMAZONE TARGETS 1-DEOXY-D-XYLULOSE 5-PHOSPHATE SYNTHASE OF NON-MEVALONATE PATHWAY IN ISOPRENOID BIOSYNTHESIS. Yurdagul Ferhatoglu, Michael Barrett, and Joe Chappell. Graduate Resaerch Assistant and Professors, Department of Agronomy, University of Kentucky, Lexington, KY 40546.

Clomazone or an active clomazone metabolite(s) is thought to inhibit chlorophyll and carotenoid biosynthesis through inhibition of a step(s) of the isoprenoid pathway. Historically, isoprenoid biosynthesis was thought to proceed from mevalonate. However, recently a second isoprenoid pathway localized in the chloroplast and proceeding from pyruvate and glyceraldehyde-3-phosphate was identified. The new chloroplast isoprenoid pathway is responsible for chlorophyll and carotenoid biosynthesis. We developed an assay using isotonic sorbitol for isopentenyl pyrophosphate (IPP) incorporation and slightly isotonic sorbitol solution for pyruvate incorporation into carotenoids to test the effect of clomazone and clomazone metabolites on the chloroplastic isoprenoid pathway. Clomazone and clomazone metabolites did not inhibit formation of products from IPP in the studies using intact spinach chloroplast. However, a clomazone metabolite 5-keto clomazone and the 1-deoxy-D-xylulose 5-phosphate (DOXP) reductosiomerase inhibitor fosmidomycin inhibited the formation of a non-polar product cochromatographed with xanthopylls when pyruvate was used as a precursor. DOXP reductoisomerase is the 2nd step in the chloroplastic isoprenoid pathway. Although 5-OH clomazone, 5-keto clomazone, and clomazone (parent) all showed herbicidal activity on periwinkel (*Catharanthus roseus*) seedlings, in an in vitro assay only 5-keto clomazone inhibited periwinkel DOXP synthase. DOXP synthase catalyzes the 1st committed step in the chloroplastic isoprenoid pathway. Our present hypothesis is that clomazone (inactive) is converted to 5-OH clomazone (inactive) which is, in turn, converted to 5-keto clomazone (active). The activity of 5-keto clomazone against DOXP synthase was also recently demonstrated by Mueller et al.(2000).

EFFECT OF PREEMERGENCE AND POSTEMERGENCE HERBICIDES ON SUGARBEET YIELD AND QUALITY. Trevor M. Dale, Karen A. Renner, Graduate Research Assistant and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824, James Stewart, Research Manager, Michigan Sugar Company, Carrollton, MI 48724 and Lee Hubbell, Research Manager, Monitor Sugar Company Bay City, MI 48707.

Sugarbeet weed control in Michigan has followed a program approach with both PRE and POST herbicide applications. Cycloate, pyrazon, or ethofumesate are applied PRE to provide residual weed control, and POST herbicides such as desmedipham & phenmedipham + triflusulfuron + clopyralid, are then applied twice (commonly referred to as a standard split application) to control weeds not controlled by the PRE herbicides. Weed control is very expensive and cultivation or hand labor is frequently needed. In 2000 the “micro-rate,” a combination of desmedipham & phenmedipham at 0.09 kg/ha or desmedipham & phenmedipham & ethofumesate at 0.09 kg a.i./ha + triflusulfuron at 0.004 kg/ha + clopyralid at 0.03 kg/ha + 1.5% methylated seed oil (MSO), received registration in Michigan. The micro-rate provides good to excellent annual weed control and allows the grower to apply POST herbicides throughout the day and not just in the evening. However, the timing of the four to five micro-rate applications is important to achieve complete weed control and some growers have reported more injury from micro-rate applications.

The objective of this study was to evaluate weed control, sugarbeet injury, yield, and quality under various herbicide programs. Herbicide treatments consisted of a factorial arrangement of five PRE herbicides, including no PRE, cycloate at 3.36 kg a.i./ha, pyrazon at 8 kg a.i./ha, ethofumesate at 1.68 kg a.i./ha, s-metolachlor at 1.42 kg a.i./ha, and five POST herbicides, including no POST, desmedipham & phenmedipham at 0.56 kg/ha + triflusulfuron at 0.017 kg/ha, desmedipham & phenmedipham & ethofumesate at 0.56 kg/ha + triflusulfuron at 0.017 kg/ha, desmedipham & phenmedipham at 0.09 kg/ha + triflusulfuron at 0.004 kg/ha+clopyralid at 0.03 kg/ha + 1.5% MSO, desmedipham & phenmedipham & ethofumesate at 0.09 kg/ha + triflusulfuron at 0.004 kg/ha + clopyralid at 0.03 kg/ha + 1.5% MSO. The experimental design was a split plot with POST treatments as the main plot and PRE treatments as the sub-plots. There were three locations, and each location had the same design with four replicates. PRE only treatments were hand weeded to determine the effect of herbicide only on sugar beet yield and quality.

Common lambsquarters control was greater than 91% in all treatments combined over locations. However, common lambsquarters control at one location increased significantly from 95% with POST herbicides to 99% when PRE herbicides were followed by POST herbicides. Redroot pigweed control was excellent with all treatments at two locations. At the site with the highest pigweed density, redroot pigweed control with the standard split application of desmedipham & phenmedipham + triflusulfuron provided 91% control, while the micro-rate of desmedipham & phenmedipham + triflusulfuron + clopyralid + MSO provided 99% control when combined over PRE herbicides.

Sugarbeet injury did not differ due to herbicide treatment when combined over locations. Sugarbeet stand and yield were reduced at one site from cycloate PRE compared to the no PRE treatment when combined over all POST treatments.

ADOPTION OF MICRO-RATE HERBICIDE APPLICATIONS IN MICHIGAN SUGARBEET PRODUCTION. Karen A. Renner, Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Weed control in sugarbeets usually requires multiple herbicide applications. Growers can either apply postemergence herbicides at standard labeled rates in split applications or apply postemergence herbicides at micro-rates and add a methylated seed oil (MSO). In 2000, 34% of Michigan's sugarbeet growers applied postemergence herbicides at micro-rates. This resulted in 41% of the sugarbeet acres being treated with micro-rates. In 2001, 56% of the sugarbeet growers applied micro-rates of postemergence herbicides which resulted in 52% of the sugarbeet acres being treated with micro-rates. Ninety percent of the micro-rate applications included desmedipham & phenmedipham (Betamix), and 98% of the micro-rate applications included triflusulfuron and clopyralid. Eighteen percent of the micro-rated sugarbeet acres were treated with a single application of clethodim, sethoxydim, or quizalofop in 2001. Seventy-two percent of the micro-rated sugarbeet acres were not treated with clethodim, sethoxydim, or quizalofop. The majority of the micro-rated sugarbeet fields received three (34%) or four (41%) micro-rate applications. Seventeen percent of the micro-rated sugarbeet acres were not cultivated in 2001. Sugarbeet injury (stunting and lack of vigor) was reported in one growing region following micro-rate applications in 2001. In previous research, micro-rate applications of desmedipham & phenmedipham were more injurious to sugarbeet than standard split applications at one of three sites, while sugarbeet response to desmedipham & phenmedipham & ethofumesate (Progress) did not differ between micro-rate and standard split applications. Therefore research was conducted in 2001 to determine sugarbeet response to standard split and micro-rate applications of desmedipham & phenmedipham, desmedipham, and desmedipham & phenmedipham & ethofumesate. These herbicide treatments included the current formulations and formulations that contained oil. Standard split treatments were applied twice, 14 days apart. All micro-rate treatments were applied four times and included triflusulfuron, clopyralid, and a methylated seed oil at 1.5%. Sugarbeet stands were reduced by 20% in plots treated with standard split applications of oily desmedipham & phenmedipham or oily desmedipham at rates of 0.56 followed by 0.56 kg/ha compared to sugarbeets treated with the current formulations of these herbicides. Sugarbeet yields were reduced in plots treated with standard split applications of oily desmedipham & phenmedipham (0.56 followed by 0.56 kg/ha) or oily desmedipham & phenmedipham & ethofumesate (0.28 followed by 0.37 kg/ha) compared to sugarbeets treated with the current formulations of these herbicides. Sugarbeet stand and yield were not reduced by either formulation of desmedipham & phenmedipham compared to the weed free control at standard split application rates of 0.28 kg/ha followed by 0.37 kg/ha. Plots treated with micro-rate applications of desmedipham & phenmedipham, desmedipham & phenmedipham & ethofumesate, or desmedipham (plus triflusulfuron, clopyralid, and MSO) had sugarbeet stands and yield equal to that of the weed free control. Sugarbeet injury was greater in micro-rate treatments containing oily desmedipham compared to the current formulation. Micro-rates of desmedipham & phenmedipham & ethofumesate or desmedipham were no more injurious to sugarbeets than standard split applications of these herbicides. However, micro-rates of the current formulation of desmedipham & phenmedipham were more injurious than standard split applications of desmedipham & phenmedipham at 0.56 kg/ha. Micro-rate treatments included triflusulfuron and clopyralid. Therefore the addition of triflusulfuron and clopyralid, the timing of micro-rate applications, the use of preemergence herbicides, and the sugarbeet variety may influence sugarbeet injury observed in grower fields treated with micro-rates in 2000 and 2001.

GLYPHOSATE RESISTANT SUGARBEET: WEED CONTROL, ECONOMICS, AND ENVIRONMENTAL IMPACTS. Andrew R. Kniss, Robert G. Wilson, Dillon M. Feuz, Paul A. Burgener and Alex R. Martin, Graduate Research Assistant, Professor, Associate Professor, and Research Analyst, University of Nebraska Panhandle Research and Extension Center, Scottsbluff, NE 69361; and Professor, Department of Agronomy and Horticulture, University of Nebraska, Lincoln, NE 68583.

A field study was initiated at two locations near Scottsbluff and Mitchell, Nebraska to compare weed control and economic benefits of the Roundup Ready (RR) system in sugarbeet to conventional and micro-rate herbicide programs. The experimental design was a split-plot with four replications. Main plots consisted of sugarbeet varieties 'Beta4546' and near isogenic 'Beta4546RR' or 'HM1640' and near isogenic 'HM1640RR'. Subplots included an untreated control, RR and non-RR handweeded controls, glyphosate applied once, twice, or three times, conventional weed control program of phenmedipham plus desmedipham plus triflusulfuron plus clopyralid applied two or three times with or without ethofumesate preemergence, and a micro-rate treatment applied three times with or without ethofumesate preemergence for a total of 12 sub-plots. All non-glyphosate herbicide treatments were applied to conventional sugarbeet varieties while glyphosate treatments were applied to glyphosate resistant varieties. Plots were 3.3m wide by 9m long and sugarbeets were planted in 56cm rows. Herbicides were applied with a tractor-mounted sprayer delivering 195 L/ha at 207 kPa pressure with 11002 nozzles. Glyphosate applied two or three times provided greater weed control than conventional treatments at both locations. One application of glyphosate did not give adequate season long weed control. The conventional herbicide treatment applied three times with or without ethofumesate provided greater weed control than micro-rate treatments. Weed control was similar between glyphosate applied two or three times, but root yield was higher at both locations when glyphosate was applied three times. Beta4546 and Beta4546RR yielded more sucrose per hectare than HM1640 and HM1640RR in all treatments at Scottsbluff, and in all but two treatments at Mitchell.

INFLUENCE OF DIFFERENT RATES OF PHENMEDIPHAM + DESMEDIPHAM + TRIFLUSULFURON METHYL + CLOPYRALID IN COMBINATION WITH MSO FOR SELECTIVE WEED CONTROL IN SUGARBEET. Robert G. Wilson, Professor, Department of Agronomy and Horticulture, University of Nebraska, Scottsbluff, NE 69361.

A field study was initiated near Scottsbluff, NE to compare weed control, crop injury, and crop yield from a series of herbicide combinations applied postemergence. A full rate of Phenmedipham + desmedipham + triflusulfuron-methyl + clopyralid at 180 + 180 + 18 + 100 g/ha was reduced by 25, 50, and 75% to achieve four rates, these four rates were combined with either 1.5 or 3% per volume of carrier of methylated sunflower oil (MSO) to achieve a total of eight treatments. Each herbicide combination was applied three times starting when the crop was in the cotyledon stage of growth. In addition, the study was split and all herbicide combinations were either applied as a band or broadcast application. When methylated sunflower oil was added at a rate of 1.5% to the full rate of herbicide, crop injury increased from 19 to 46%, weed control remained unchanged, and sugarbeet root yield declined. Reducing the herbicide rate by 25, 50, and 75% resulted in a decline in crop injury from 46 to 31 to 19 to 9%, respectively. As herbicide rate was reduced 25, 50, and 75% redroot pigweed control declined from 95 to 93 to 81 to 78%, respectively. Sugarbeet injury was not influenced by herbicide application method, however redroot pigweed, hairy nightshade, and common lambsquarters control was greater when herbicides were banded.

CONTROL OF KOCHIA WITH FLUROXYPYR IN SUGARBEET. Donald L. Vincent III, Alan G. Dexter, and John L. Luecke, Graduate Research Assistant, Professor, and Research Specialist, Department of Plant Sciences, North Dakota State University - University of Minnesota, Fargo, ND 58105

Fluroxypyr is an auxinic herbicide registered in wheat and barley at 0.14 kg ae/ha for control of kochia, but efficacy and crop response in sugarbeet are not known. The objective of these experiments was to investigate kochia control and sugarbeet injury from fluroxypryr in combination with conventional sugarbeet herbicides.

Experiments were conduced in fields near Felton and Humbolt, MN, and Hillsboro and St. Thomas, ND, in 2000 and near Felton, MN, and Glasston, Manvel, and St. Thomas, ND, in 2001. Yield of weed free sugarbeet was measured at St. Thomas, ND, in 2000 and 2001, and weed control evaluations were taken at all other locations. A micro-rate treatment of desmedipham & phenmedipham at 0.045 & 0.045 kg ai/ha plus triflusulfuron at 0.004 kg ai/ha plus a methylated seed oil adjuvant at 1.5% v/v was applied four times at approximately 7 d intervals. Fluroxypyr was applied at 0.017, 0.034, 0.067, and 0.14 kg ae/ha in either the second, third, or fourth application of the micro-rate, or applied alone 7 or 14 d after the last micro-rate treatment.

Kochia control in 2000 and 2001 increased as the rate of fluroxypyr increased from 0.017, 0.034, 0.067, to 0.14 kg/ha. The level of control was less in 2001 than in 2000. The micro-rate plus fluroxypyr at 0.017 kg/ha gave 92% kochia control in 2000 but only 68% control in 2001. The 0.034, 0.067, and 0.14 kg/ha rates of fluroxypyr provided better kochia control than 0.017 kg/ha or the micro-rate alone. Kochia control from the micro-rate plus fluroxypyr in 2000 ranged from 92 to 98% but in 2001 ranged from 68 to 87%

Sugarbeet injury was similar in 2000 and 2001. Sugarbeet injury was greater when fluroxypyr was applied at any rate or timing than when the micro-rate was applied alone. In both years, sugarbeet injury increased as the rate of fluroxypyr was increased. In both 2000 and 2001 sugarbeet treated with 0.017 kg/ha fluroxypyr did not have reduced yield compared to sugarbeet treated with the micro-rate alone, but did have reduced yield with fluroxypyr at 0.034, 0.067, and 0.14 kg/ha.

Fluroxypyr at 0.017, 0.034, 0.067, and 0.14 kg/ha was added in 2000 to the third application or applied alone 7 d after a conventional rate of desmedipham & phenmedipham at 0.14 & 0.14 kg/ha. Sugarbeet treated with fluroxypyr at 0.14 kg/ha in the third application or 7 d after the last application of desmedipham & phenmedipham yielded less extractable sucrose than sugarbeet treated with desmedipham & phenmedipham alone. Fluroxypyr applied alone 7 d after the conventional rate caused less sugarbeet injury than fluroxypyr plus the conventional rate.

Fluroxypyr was applied alone 7 or 14 d after the last micro-rate treatment in 2001. Sugarbeet treated four times with the micro-rate followed by fluroxypyr at 0.017, 0.034, 0.067, and 0.014 kg/ha applied 7 or 14 d after the last micro-rate treatment yielded less than sugarbeet treated four times with the micro-rate alone.

CONTROL OF KOCHIA WITH REGISTERED HERBICIDES IN SUGARBEET. Alan G. Dexter, Donald L. Vincent III and John L. Luecke, Professor, Graduate Research Assistant and Research Specialist, Plant Sciences Department, North Dakota State University and the University of Minnesota, Fargo, ND 58105.

Kochia resistant to ALS-inhibiting herbicides is widespread in the Red River Valley of North Dakota and Minnesota. Triflusulfuron gives excellent selective control of non-resistant kochia in sugarbeet but no control of resistant kochia. The objective of this experiment was to determine control of ALS-resistant kochia with various combinations and rates of herbicides registered for use on sugarbeet. The experiment included 28 treatments and was established near Glasston, St. Thomas, and Manvel, ND and Felton, MN in 2001. Plots at St. Thomas were hand weeded throughout the season and were harvested. The other three sites were evaluated for kochia control but were not harvested. The 'micro-rate' POST treatment was desmedipham & phenmedipham & ethofumesate + triflusulfuron + clopyralid + clethodim + methylated seed oil at 0.09 + 0.004 + 0.03 + 0.03 kg/ha + 1.5 % v/v applied four times at a weekly interval. The 'conventional rate' POST treatment was desmedipham & phenmedipham & ethofumesate + triflusulfuron + clethodim applied three times at a weekly interval at 0.28 + 0.009 + 0.04/0.37 + 0.009 + 0.04/0.56 + 0.009 + 0.04 kg/ha. The first POST treatments were applied to cotyledonary sugarbeet. Ethofumesate at 3.4 kg/ha and metolachlor at 1.7 kg/ha were applied PRE and EPTC + cycloate at 1.1 + 2.2 kg/ha was applied PPI to some plots.

Kochia at the three locations was nearly totally ALS resistant since desmedipham & phenmedipham & ethofumesate at the conventional rate averaged 67% kochia control while desmedipham & phenmedipham & ethofumesate + triflusulfuron gave 73% control. Kochia control from the conventional rate was 69% and from the micro-rate was 46%. Desmedipham & phenmedipham & ethofumesate applied three times at 0.28 kg/ha gave 48% kochia control while desmedipham & phenmedipham & ethofumesate applied three times at 0.28/0.37/0.56 kg/ha gave 73% control. POST herbicides over PRE or PPI herbicides gave better kochia control than POST alone. The best kochia control was from ethofumesate PRE or EPTC + cycloate PPI followed by the conventional rate of POST herbicides but the level of control was only 84% and 86%, respectively averaged over three locations.

The addition of extra ethofumesate at 0.25 kg/ha to the micro-rate and the conventional rate did not significantly improve kochia control. The herbicide treatments did not affect extractable sucrose yield from hand weeded sugarbeet at St. Thomas as compared to the hand-weeded untreated check.

WEED MANAGEMENT AND HYBRID TOLERANCE WITH MESOTRIONE IN SWEET CORN.
Stephen M. Sanborn, Research and Development Scientist, Syngenta Crop Protection, Greensboro, NC 27419.

Mesotrione (2-[4-methylsulfonyl-2-nitrobenzoyl]-1,3-cyclohexanedione) at 210 or 420 g ai/ha applied preemergence and 105 or 210 g ai/ha applied postemergence was evaluated for crop selectivity and weed control in sweet corn. Effects of the postemergence spray additives 1 % v/v crop oil concentrate (COC), 0.25 % v/v non-ionic surfactant (NIS), and 2.5% v/v urea ammonium nitrate (UAN) were also evaluated. Sweet corn hybrids were chosen for evaluation based on their importance to the processing industry in the North Central United States. Preemergence applications of 210 or 420 g ai/ha mesotrione were very safe to all sweet corn hybrids tested at all but one location. Postemergence applications of 105 g ai/ha mesotrione with either COC or NIS were also very safe to all hybrids. However, when COC plus UAN was used as an additive, postemergence applications of 105 g ai/ha mesotrione caused significant injury (bleaching) in some, but not all, hybrids. This effect was rate dependent as significantly more injury was observed at the 210 g ai/ha rate. Sweet corn yields were not affected by the injury from 105 g ai/ha mesotrione + COC + UAN applied postemergence. Mesotrione provided good control of several broadleaf weed species at 210 g ai/ha applied preemergence and at 105 g ai/ha + COC or NIS applied postemergence. Results of these studies indicate that mesotrione has good potential for weed control in sweet corn for processing.

INTEGRATING METOLACHLOR AND RIMSULFURON INTO PROCESSING TOMATO PRODUCTION SYSTEMS. Joel Felix* and Douglas J. Doohan, Postdoctoral Research Associate and Assistant Professor, Department of Horticulture and Crop Science, The Ohio State University, Wooster, OH 44691

Field studies were conducted in 1999 and 2000 at the Ohio Agricultural Research and Development Center near Fremont OH to determine the complementary effects of rimsulfuron and *s*-metolachlor for weed management in processing tomato production systems. 'Hypeel 696' tomato seedlings were transplanted on 90 cm by 3 m seedbeds, and 30 cm within the row. *S*-metolachlor was applied at 1.4 kg ai/ha either as PPI, POST-broadcast, POST-directed stand alone treatments or followed by rimsulfuron and metribuzin POST at 18 and 630 g ai/ha, respectively. All POST treatments included Induce™ nonionic surfactant at 0.25% V/V. Tomato plant growth inhibition and weed control were assessed at 7, 21, and 42 days after treatment (DAT) on a scale of 0 (no apparent injury) and 100% (total crop death or weed control). Except for rimsulfuron + metribuzin POST, all treatments resulted in ≥ 98% pigweed (*Amaranthus* spp.), common purslane (*Portulaca oleraceae* L), and common lambsquarters (*Chenopodium album* L.) control at 7 DAT. Evaluations done at 21 and 42 DAT had ≥ 90% weed control except for *s*-metolachlor POST-broadcast and POST-directed treatments. Also, POST-broadcast and POST-directed s-metolachlor treatments did not control eastern black nightshade and were accompanied by 36 and 18% tomato yield reduction, respectively. Transent (<2 WAT) crop injury was observed following *s*-metolachlor and rimsulfulrion POST applications. Excellent eastern black nightshade control was achieved with s-metolachlor (PPI) + rimsulfuron (POST) treatment. Treatments including rimsulfuron had excellent annual grass and quack grass (*Elytrigia repens* (L.) nevski) control with Canada thistle (*Cirsium arvense* L.) suppression. There was no tomato yield reduction with *s*-metolachlor (PPI) followed by rimsulfuron up to 54 g ai/ha (POST). *s*-metolachlor (PPI) followed by rimsulfuron improved weed control especially triazine resistant common lambsquarters.

COVER CROPS AS AN ALTERNATIVE METHOD OF WEED MANAGEMENT IN POTATO.
Becky B. Gleichner*, Larry K. Binning, and Chris M. Boerboom. Graduate Research Assistant, Professor, and Associate Professor, Univ. of Wisconsin-Madison, WI 53706.

Early-season weed control is important to obtain high potato yields and quality. Potential economic benefits associated with reduced herbicide applications have stimulated interest in alternative and integrated weed management strategies. Short-season cover crops seeded at or near the time of potato planting may provide an alternative to conventional weed management strategies by suppressing early-season weed growth. Therefore, field experiments were conducted at the Hancock Agricultural Research Station in Hancock, Wisconsin to evaluate the influence of cover crop seeding density, and seeding time on weed biomass and potato yield.

Main plots were planted to Burbank or Superior potatoes on April 27, 2000 and April 26, 2001 in 91-cm rows. Subplots were yellow mustard (*Brassica rapa*) or Wisconsin fastplant (*Brassica campestris*) seeded at rates of 200, 350, or 500 seeds m^{-2}. Within each subplot, cover crops were planted at potato emergence or at 1 or 2 wks after potato emergence. Control treatments were metribuzin (PRE) at 0.41 kg ai ha^{-1} and rimsulfuron (POST) at 0.018 kg ai ha^{-1} and a weed free check. Plots were arranged in a randomized complete block with three replications.

Cover crop densities did not affect marketable tuber yield or weed biomass in 2000 and 2001. Weed biomass was harvested prior to vine kill and potatoes were harvested for yield. Although there were no significant treatment or timing main effects, or type*timing interactions in 2000; cover crops seeded at 1 wk after potato emergence decreased weed biomass 6% compared to cover crops seeded at potato emergence. Weed biomass for Wisconsin fastplant seeded at 200 seeds m^{-2}, was similar to the herbicide treatment and weed free check. In 2001, treatment and timing main effects were significant, indicating a 42% decrease in weed biomass when cover crops were seeded 2 wks after potato emergence. Wisconsin fastplant seeded at 200 seed m^{-2} was similar to the herbicide treatment. Yield was reduced 3% in 2000 and 14% in 2001 when cover crops were seeded at potato emergence. Total marketable potato yield was greatest in 2000 when Wisconsin fastplant was seeded 1 wk after potato emergence and 2 wks after potato emergence in 2001. Also in both years, marketable tuber yields for Wisconsin fastplant seeded at 200 seeds m^{-2}, were similar to the herbicide treatment and weed free check. This suggests that Wisconsin fastplant may be a viable alternative to current weed management strategies in the potato production system.

ALTERNATIVE WEED CONTROL METHODS FOR CARROT PRODUCTION IN EUROPE AND MICHIGAN. Juan J. Cisneros and Bernard H. Zandstra, Graduate Research Assistant and Professor, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Sustainable crop production involves farming systems that are socially acceptable, agronomical and economically viable, and environmentally safe. As a result of this new vision, people are demanding food produced with few or no pesticide inputs. Carrot is an important crop for Michigan with a production value of $16,717,000 in 1999. Carrot is a poor competitor early in the season. For this reason, herbicides are very important in carrot production. Europe is addressing this problem with physical methods of weed control, including flaming before carrot emergence and a Hoe-Torsion-Weeder cultivator after carrot emergence. Due to the differences between American and European farming systems, current European approaches can't be transposed to the US without appropriate modifications. Greenhouse and field studies were conducted to test the activity of several new herbicides on different weed species and to assess the tolerance of carrot. In the greenhouse flumioxazin, sulfentrazone, and oxyfluorfen caused minimal injury to carrot. Preemergence flumioxazin rate were 0.001, 0.005, and 0.01 lb/A; 0.1 and 0.2 lb/A (sulfentrazone); 0.2 and 0.4 lb/A (oxyfluorfen). Postemergence rates were: 0.02, 0.04, and 0.06 lb/A (flumioxazin); 0.03, 0.06 and 0.12 lb/A (oxyfluorfen). In field trials the three herbicides gave yield similar to linuron. In the greenhouse, sulfentrazone caused no significant injury on carrot, but in the field it caused significant reduction of plant stand but no reduction in yield. The effect of adding surfactant to flumioxozin resulted in reduced yield.

WEED CONTROL OPTIONS IN ONION. Harlene M. Hatterman-Valenti, Paul E. Hendrickson, and Richard G. Greenland, Assistant Professor, Research Specialist, and Research Agronomist, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105-5051.

Weed management is extremely important in onion due to the few herbicides registered for onion, the application restrictions of many of the herbicides that are registered, and the inability of the slow emerging, shallow rooted onion to compete with weeds. Field studies were conducted at three locations to evaluate the performance of various herbicides and herbicide combinations for early season weed control in onion. Preemergence and preplant incorporated applications of flumioxazin at 0.05 or 0.11 kg ai/ha injured onion and reduced stands compared to other treatments. Ethofumesate applied preemergence at 2.24 or 4.5 kg ai/ha was considered safe to onion but did not provide adequate control of common lambquaters, Eastern black nightshade, hairy nightshade, redroot pigweed, or wild mustard by 7 weeks after application. Bromoxynil applied as a delayed preemergence application (seven to ten days after planting) at 0.28 kg ai/ha in combination with pendimethalin at 0.7 kg ai/ha to one-leaf onion provided early-season control of all broadleaf and grass weeds present in the three trials without injury to onion. Pendimethalin at 0.7 kg ai/ha to one-leaf onion provided early-season green foxtail control but did not provide adequate broadleaf control. Urea-ammonium nitrate (28% N) fertilizer applied postemergence at 140, 187, or 234 L/ha to one-leaf onion did not injure onion or provide additional broadleaf control.

LATE-SEASON WEED CONTROL IN ONION. Richard G Greenland, Harlene Hatterman-Valenti, and Paul Hendrickson. Research Supervisor, Oakes Irrigation Research Site; Assistant Professor, Plant Sciences Department; Irrigation Specialist, Carrington Research/Extension Center; North Dakota State University, Fargo, ND 58105.

Late season weed control is difficult in onions because the onion plants do not shade the ground during the season and the effect of herbicides wanes as the season progresses. Flumioxiazin applied preplant incorporated, DCPA, pendimethalin and ethofumesate applied preemergence, and pendimethalin, metolachlor, dimethenamid-P, and sulfentrazone, applied at the 3-leaf stage of onion growth, were studied to determine their ability to control late emerging weeds in onion. These studies were done at Oakes (sandy loam soil) in 2000 and 2001, and at Fargo (clay soil) and Carrington (silt loam soil) in 2001.

At Oakes in 2000, metolachlor and dimethenamid applied at the 3 to 5-leaf stage of onions (and proceeded by burn down herbicides) gave good to excellent season long control of redroot pigweed. Pendimethalin applied similarly gave fair to good control. In 2001, redroot pigweed control was only fair to good with these three herbicides applied at the 3-leaf onion stage. DCPA applied preemergence, and metolachlor, dimethenamid, and pendimethalin applied at the 3-leaf stage controlled late emerging common purslane. Sulfentrazone applied at the 3-leaf onion stage gave excellent late season control of all weeds but delayed onion maturity.

At Fargo and Carrington, DCPA applied preemergence, and pendimethalin, dimethenamid, metolachlor, and sulfentrazone applied at the 3-leaf onion stage gave good to excellent season long control of redroot pigweed and lambsquarters.

Onion injury and/or poor early season weed control made flumioxiazin and ethofumesate unacceptable choices for late season weed control in onion.

FALL APPLICATION OF IMAZAQUIN PLUS GLYPHOSATE (PREMIX) FOR WINTER ANNUAL WEED CONTROL IN SOYBEANS. Brian J. Dahlke*, Tom A. Hayden, John W. Leif and Case R. Medlin, BASF. Corp., Seymour, IL 61875, Owensboro, KY 42301 and St. Johns, MI 48879, and Purdue Univ., West Lafayette, IN, currently Oklahoma State Univ., Stillwater 74078.

Increasing winter annual weed problems in the Midwest have been attributed to a reduction in the use of soil residual herbicides during the cropping season, increased use of no-till production practices, and several successive mild winters. In the fall of 2000, trials were initiated at three BASF field test sites and at three locations in Indiana to evaluate imazaquin plus glyphosate (Backdraft®[1]) tank-mixed with 2,4-D for control of winter annual weeds. These trials utilized application rates higher than those specified in the approved label directions.[2] Commercial comparisons also evaluated were, chlorimuron ethyl plus sulfentrazone (Canopy® XL[3]) and chlorimuron ethyl plus sulfentrazone tank-mixed with tribenuron methyl. Evaluations were recorded in spring before planting. Imazaquin plus glyphosate applied at 0.125+0.5 lb ai/A plus 0.5 lb ai/A 2,4-D provided at least 93% control of common chickweed (*Stellaria media*), henbit (*Lamium amplexicaule*), purple deadnettle (*Lamium purpureum*) and annual bluegrass (*Poa annua*), comparable to the commercial treatments. Potential benefits of controlling these weeds in the fall include: 1. better planting conditions in the spring resulting in more uniform soybean stands due to warmer and drier soils, 2. a reduction of alternate hosts for soybean cyst nematode and other pests, 3. ease of tillage in the spring, 4. a reduced need or increased activity of spring burn-down treatments, and 5. a better distribution of applicator workloads throughout the year.

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[1] Backdraft is a trademark of BASF Corporation

[2] The results presented are provided for informational purposes and are not intended to promote the use of products other than as instructed in the EPA approved labeling. Any sale of the product shall be solely on the basis of the EPA approved product label and any claims regarding product safety and efficacy shall be addressed slowly by the label.

[3] Canopy is a trademark of E. I DuPont

LOW-RATE SPLIT-APPLIED HERBICIDE TREATMENTS IN SOYBEAN. Brad K. Ramsdale and Calvin G. Messersmith, Postdoctoral Research Fellow and Professor, Department of Plant Sciences, North Dakota State University, Fargo, 58105.

Experiments were conducted to examine the potential of reducing imazamox and imazethapyr rates in soybean by split application. 'AG 0901' soybean in 2000 and 'AG 0801' soybean in 2001 was planted in 30-inch rows in east central North Dakota. All treatments were applied with a bicycle-wheel-type plot sprayer equipped with four 8001 flat-fan nozzles (20-inch spacing) at 8.5 gal/A spray volume and 35 psi spray pressure. Plots were 10 by 30 ft and arranged in a randomized complete block with four replicates. Treatments were either a single application or two applications each at one-half the single rate. Both herbicides were applied with nonionic surfactant plus 28% N, basic blend, or methylated vegetable oil adjuvants, which provided similar efficacy of these herbicides.

The results in 2000 were that yellow foxtail and common cocklebur control by imazethapyr at 0.25 or 0.38 oz ai/A applied once was approximately 30 and 10 percentage points less than by imazethapyr at 0.75 oz/A applied once. However, imazethapyr at 0.25 or 0.38 oz/A in two 0.125- or 0.19-oz/A treatments, respectively, provided similar control to imazethapyr at 0.75 oz/A applied once. Similarly, yellow foxtail and common cocklebur control by imazamox applied once decreased by approximately 20 and 50 percentage points as the rate was reduced from 0.5 oz/A to 0.25 or 0.15 oz/A, respectively. However, imazamox at 0.15 or 0.25 oz ai/A in two 0.075- or 0.125-oz/A treatments, respectively, provided yellow foxtail control comparable to imazamox at 0.5 oz/A applied once. Also, imazamox at 0.25 oz/A in two 0.125-oz/A treatments provided common cocklebur control similar to imazamox at 0.5 oz/A applied once.

Imazethapyr and imazamox provided better weed control in 2001 than 2000, which minimized differences among treatments. Imazethapyr as split-applied treatments at one-third to one-half rate provided greater yellow foxtail control compared to equivalent rates applied once and were similar to the full-rate applied once. Common cocklebur control by imazethapyr was generally similar among all treatments, although reduced-rate split-applied treatments provided more consistent control that was equal to or greater than the full-rate treatment. Imazamox as split-applied treatments at one-third or one-half rate provided greater yellow foxtail control and equal or greater common cocklebur control compared to the equivalent rates applied once. Additionally, imazamox as split-applied treatments generally required one-half rate (0.25x + 0.25x) to provide equal control as the full-rate of imazamox applied once.

Overall, soybean yields were low in 2000 (25 bu/A or less) and generally did not relate to visual estimates of weed control. Standing water was present in much of the experimental area due to heavy rains in June. As a result, soybean maturity was delayed and yields were variable. Soybean yield in 2001 ranged from 27 to 42 bu/A following herbicide treatment compared to 12 bu/A for untreated plots and related closely to visual estimates of weed control. Soybean yields in 2001 were generally best for reduced-rate split-applied treatments of imazethapyr and imazamox, and were equal to or greater than full-rate treatments applied once.

GLYPHOSATE AND GLYPHOSATE TANKMIXES FOR CONTROL OF MORNIGGLORY IN SOYBEAN. Keith Mohr and Reid J. Smeda, Graduate Research Assistant and Assistant Professor, Agronomy Department, University of Missouri, Columbia, MO 65211.

Despite broad-spectrum weed control with glyphosate, some species such as morningglory are not consistently controlled. However, effective control of morningglory is necessary because plants are prolific seed producers and reduce soybean yield. Due to inconsistent morningglory control, combinations of glyphosate with low rates of other herbicides may be beneficial.

Field studies were conducted in central and northeast Missouri in 1999, 2000, and 2001 to determine the effect glyphosate rate, application timing, and the addition of one of four postemergence broadleaf herbicides on morningglory control, seed production, and seed viability. Glyphosate-resistant soybean was drilled in 19 cm rows in late May and early June. Morningglory (10 cm) was treated with a single application of 0.63, 0.84, 1.05, or 1.26 kg ae/ha glyphosate or a sequential application of 0.84 kg/ha followed by either 0.63 or 0.84 kg/ha at 8 cm weed regrowth. Tankmix treatments included either 17.5 or 35 g ae/ha 2,4-DB, 4.4 g ai/ha chlorimuron, 140 g ai/ha fomesafen, or 8.8 g ai/ha cloransulam in addition to 0.63 or 0.84 kg/ha glyphosate. Applications of 0.84, 1.05, or 1.26 kg/ha glyphosate were also made to 15 cm (initial vining) morningglory. Above ground fresh weight of 4 treated morningglory plants/plot was measured 2 WAT. Prior to soybean harvest, morningglory were harvested and seeds/plant was counted. A tetrazolium test was conducted to determine seed viability.

Glyphosate only treatments reduced plant weight 6 to 55% compared to untreated plants, but differences among treatments were seldom significant within site-years. Increasing glyphosate rate from 0.63 to 0.84 kg/ha with an additional herbicide did not usually increase morningglory control. With the exception of fomesafen and chlorimuron, the addition of another herbicide to glyphosate did not significantly improve morningglory control over the equivalent rate of glyphosate alone. Overall, sequential applications of glyphosate or the addition of fomesafen consistently provided the highest levels of morningglory control. Morningglory seed production and viability were highly variable within and between years. Environmental conditions may have a greater effect on seed number and viability than herbicide treatment. Due to dry environmental conditions, there were no significant differences in seed production or viability in the untreated and handweeded controls in 2 out of 5 site-years. In the other 3 site-years, all treatments and handweeded controls were significantly different from the untreated controls. Nearly all treatments reduced seed production to less than 1 seed/plant, while untreated controls yielded 5 to 70 seeds/plant. Seed viability in all treatments was less than 5% while seeds not treated ranged from 15 to 65% viability.

COMPARISON OF MICRONUTRIENT UPTAKE BY GLYPHOSATE RESISTANT AND NON-GLYPHOSATE RESISTANT SOYBEANS. Darrin M. Dodds, Michael V. Hickman, and Don M. Huber, Graduate Research Assistant, Adjunct Professor, and Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Transient foliar chlorosis following application of glyphosate to glyphosate-resistant soybeans has been observed over the last several years. Increased reports of manganese deficiency after adoption of this technology prompted this evaluation of micronutrient efficiency in glyphosate-resistant compared with non glyphosate-resistant soybeans. Field plots were established on a silt loam known to be manganese limiting and another silt loam soil considered to be fully micronutrient sufficient. Differences in growth, micronutrient deficiency symptom expression, and Inductively Coupled Plasma – Atomic Absorption (ICP-AA) analysis of tissue were recorded. Copper, manganese, and zinc micronutrients were applied as seed treatments or foliar treatments in a replicated, complete block design. There was little difference in growth or color of the two soybean genotypes on the fully sufficient micronutrient soil throughout the growing season. In contrast, the glyphosate-resistant soybeans were shorter and developed severe manganese deficiency symptoms on the manganese marginal soil. Tissue analyses indicated that the glyphosate-resistant genotype was less efficient in micronutrient uptake and utilization. Although this gene confers glyphosate resistance, it also influences uptake and tissue concentrations of micronutrients. These differences may have significant influence on susceptibility to diseases as well as overall growth and vigor under adverse soil and environmental conditions.

RISK ANALYSIS OF SOYBEAN WEED MANAGEMENT SYSTEMS OVER TIME AND ENVIRONMENTS. Thomas R. Hoverstad, Jeffrey L. Gunsolus, Robert P. King and Gregg A Johnson, Scientist, Professor, Professor and Professor, University of Minnesota, Department of Agronomy and Plant Genetics, University of Minnesota. St Paul, MN 55108.

The objective of this study was to measure economic returns of herbicide and mechanical weed management systems and use risk analysis techniques to evaluate economic returns in addition to weed control performance for these systems. Weed management systems were evaluated in small plot replicated trials over a six-year time period at two locations in southern Minnesota. Adjusted gross returns were calculated for each system by measuring economic returns as determined by deducting weed management costs from the product of soybean price and soybean seed yield. Adjusted gross returns for the six-year time period were subjected to mean-variance and stochastic dominance risk analysis techniques. These results were compared to more traditional mean separations statistical techniques for herbicide efficacy, seed yield and economic returns. In an environment that had grass weeds along with a high population of common ragweed a one-pass soil applied weed management system resulted in lower yields and a high level of variability in adjusted gross returns compared to a two-pass system that controlled grass weeds with a soil applied herbicide and broadleaf weeds postemergence. This same one-pass weed management system resulted in lower risk and compared much more favorably to two-pass systems in an environment that had very little competition from broadleaf weeds.

SOYBEAN WEED MANAGEMENT WITH FALL APPLIED HERBICIDES. Romina Güeli and Reid J. Smeda, Graduate Research Assistant and Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211

During the last five years, weed control programs for soybean production have shifted dramatically from utilization of PRE and POST products to glyphosate alone on transgenic soybean. As a result, the lack of soil residual herbicides, combined with some recent mild winters, has led to increasing populations of winter annual and biennial weeds.

Field experiments were conducted at two Missouri locations (central and northeast) to evaluate the efficacy of fall applied versus conventional applied herbicide programs for winter and summer annual weed control and soybean yield. Fall treatments were applied in mid-November 2000, and included numerous herbicides at rates at or below those recommended as spring applications. In addition, 2,4-D at 0.56 kg/ha a.i. plus crop oil crop concentrate was added for initial weed control. Spring treatments included reduced rates of PRE herbicides or different timings of glyphosate or paraquat. All treatments received 0.84 kg ae/ha of glyphosate five weeks after planting to allow early, but not late-season weed competition.

Percent control was recorded for winter and summer annual weeds in early March and at planting (mid-May). Henbit, smallflowered bittercress, annual bluegrass, and common chickweed control was excellent and similar for all fall applied treatments up to early May. However, control of summer annuals such as giant foxtail, waterhemp, and common ragweed in mid-May was inconsistent. Applications of glyphosate or paraquat within 2 weeks of planting resulted in good to excellent control of most winter and summer annuals. Delayed planting in central Missouri, due to wet conditions, led to high populations of summer annual weeds following planting. Delayed planting also led to variable results with soybean yield. Use of sulfentrazone plus chlorimuron, flumioxazin, or chlorimuron plus tribenuron-methyl provided the highest yields among fall applied treatments at both locations. In central Missouri, yields for spring applied treatments were lower than some fall applied treatments. In northeast Missouri, yields for spring applied treatments such as sulfentrazone plus chlorimuron or glyphosate alone were highest, and comparable to the highest yielding fall applied treatments.

GLYPHOSATE RAINFAST INTERVAL. Fred W. Roeth, Irvin L. Schleufer, and Perry Ridgway, Professor and Research Technicians, University of Nebraska South Central Research and Extension Center, University of Nebraska, Clay Center, NE 68933

Two glyphosate-formulated products with different glyphosate salts and inert ingredients were evaluated and compared for their rainfastness in two field studies during June and August, 2001. Glyphosate isopropylamine (Gipa, brand name Roundup Ultra Max) and glyphosate diammonium salt (Gdas, brand name Touchdown), were applied at .84 ae/ha volunteer corn at the 40 cm height and a weed complex of velvetleaf, foxtails, and waterhemp at the 15 to 25 cm height. Volunteer corn, the most uniform species, was used as the primary indicator of herbicide efficacy. Washoff times were 15, 30, 60, 90, 120, and 180 min after application. Herbicides were applied in water at 187 l/ha with ammonium sulfate at 1.5% for Gdas and 2.0% for Gipa. Several untreated and unwashed treated checks were used as controls. Applications were initiated at 0900 hr with washoff beginning at 1200 hr with 2.0 cm irrigation water applied in 40 min. Irrigation water temperature was 12 C. On the June 22 and August 20 treatment dates, air temperatures at 1200 hr were 25 and 27 C, respectively; and the relative humidities were 42 and 59%, respectively. Plants were not drought or heat stressed at any time. Plant injury evaluations were made 7, 10, and 14 DAT. Ten corn plants per plot were cut at ground level, dried, and weighed at 17 DAT.

In the June study, Gipa was consistently more effective than Gdas across washoff times, but both formulations reduced corn weight by 80% or more at each washoff time. Corn injury at 14 DAT was more variable but showed the same trend. The 180 min washoff showed complete effectiveness on the corn. In the August study, complete corn kill was achieved at 120 min, but the two glyphosate formulations did not differ in rainfastness. Although weed populations were more variable than corn, the weed and corn injury data agreed.

The two studies showed general agreement in their efficacy curves across washoff times; however, the June study indicated a glyphosate formulation difference that was not evident in the August study. Both formulations had rapid initial sorption as shown by the 15 and 30 min washoff times. The difference in the two studies could be due to relative humidity or solar radiation. The June 22 environment had 17% lower relative humidity and 15% higher radiation per daylight hour, but daytime temperatures were similar.

SOYBEAN RESPONSE TO PLANT GROWTH REGULATOR HERBICIDES. Kevin B. Kelley, Loyd M. Wax, Aaron G. Hager, and Dean E. Riechers, Graduate Research Assistant, Professor, Extension Specialist and Assistant Professor, Department of Crop Sciences, University of Illinois and USDA- ARS, Urbana, IL 61801.

Plant growth regulator (PGR) herbicides are widely used in corn production due to their effectiveness at controlling broadleaf weeds and ALS/triazine resistant weeds. However, soybeans are very sensitive to exposure to these herbicides. At low doses, they cause abnormal foliar symptoms and can adversely affect crop development. Symptoms resembling growth regulator injury are commonly reported during the growing season, and there are various ways that a soybean crop can come in contact with a PGR herbicide. Often, it is difficult to trace abnormal foliar symptoms to a PGR herbicide exposure, and other stresses such as soybean viruses can cause symptoms that can be mistaken for PGR herbicide injury. There are currently no diagnostic tools available to determine whether or not symptoms observed in the field are do to PGR herbicide exposure or some other source. Field studies were conducted in 2000 and 2001 to characterize the effects of PGR herbicides on soybeans. Also, laboratory experiments are currently underway to develop a diagnostic assay to conclusively identify or rule out PGR herbicides as the causal agent of abnormal foliar symptoms in the field. Field experiments included the PGR herbicides dicamba, dicamba plus diflufenzopyr, clopyralid, and 2,4-D, and also imazethapyr, glyphosate and fomesafen applied to glyphosate-resistant soybeans. The PGR herbicides were applied at two low rates that simulate unintentional applications to soybeans. These rates were applied at early vegetative (V2) and early reproductive (R2) stages in 2000, and at early vegetative (V2), late vegetative (V6) , and early reproductive (R2) stages in 2001. The PGR herbicides caused varying levels of injury to soybeans, affecting plant height, leaf area and date of maturity. Only the treatments causing the most severe injury resulted in reduced yield. Apparently, soybeans are able to compensate for injury by increasing branching and/or pod number. Soybeans are more sensitive to dicamba than clopyralid, and more sensitive to clopyralid than 2,4-D. Differences were noted in foliar symptoms among the PGR herbicides that may aid in identifying them as the cause of injury symptoms in the field. Symptoms of dicamba injury include leaf cupping of the newly emerging leaves. However, clopyralid and 2,4-D often cause newly emerging leaves to be more strapped with parallel veins, although some leaf cupping can also be observed.

MECHANISMS INVOLVED IN WEED SPECIES SHIFTS IN A GLYPHOSATE TOLERANT SYSTEM. Kari L. Hilgenfeld, Alex R. Martin, Stephen C. Mason, and Dave A. Mortensen, Graduate Research Assistant, Professor, Professor, Department of Agronomy and Horticulture, University of Nebraska, Lincoln, NE 68583-0915, and Professor, Department of Crop and Soil Sciences, Penn State University, University Park, PA 16802.

Since the development of glyphosate tolerant soybeans, many farmers have simplified weed management practices, becoming more reliant on glyphosate for weed management. When changes in management practices are made, shifts in the problematic weed species often occur. Shifts in species could limit the long-term sustainability of glyphosate as a management practice. Understanding the mechanisms involved in the weed species shift should aid in development of robust weed management systems. A field study documented species shifts in a continuous glyphosate system. It was hypothesized that the shift in species was due to the ability of the weed to naturally tolerate glyphosate or avoid glyphosate by emerging after treatments. Two studies were utilized to evaluate the contribution of these mechanisms in the species shift.

The focus of the first study was the affect of time of weed emergence on weed species success in the glyphosate system. It was set up as a RCBD. Seedbanks of common lambsquarters, common sunflower, common waterhemp, eastern blacknightshade, ivyleaf morningglory, shattercane, and woolly cupgrass were established in the field to represent different emergence patterns and glyphosate tolerance levels. The square meter seedbanks were established in the center of six-row plots of soybeans, 4 m in length. Four treatments, an early application of glyphosate (20-25 DAP), a late application of glyphosate (30-35 DAP), an early application (20-25 DAP) followed by a late application of glyphosate (50-55 DAP), and no herbicide application were tested on the seven weed species. The glyphosate rate utilized was 630 g ae ha^{-1} applied at 93.5 L ha^{-1}. Weekly population counts were recorded to observe weed emergence and the effect of glyphosate on the weed population.

The focus of the second study was to evaluate the differential sensitivity of the seven species to glyphosate. The study was set up as a RCBD. Each experimental unit was a 2.5 m row of the selected species. The glyphosate rate tested was 630 g ae ha^{-1} applied at 93.5 L ha^{-1}. Visual efficacy ratings were made 15 days after the glyphosate application.

Ivyleaf morningglory populations increased in the glyphosate system due to its ability to tolerate glyphosate applications and emerge throughout the season. Extended emergence allowed shattercane population to increase under the glyphosate system although it is sensitive to glyphosate treatments. Common waterhemp, eastern blacknightshade, woolly cupgrass, and common sunflower produced a few plants that were able to escape glyphosate treatments if applications were made early in the season. Common lambsquarters was not successful in the glyphosate system due to its early emergence pattern and sensitivity to glyphosate. As hypothesized, time of emergence and differential sensitivity had a significant role in weed species shifts in a glyphosate system. This study should aid in developing integrated weed management (IWM) systems that will effectively prevent and manage weed shifts that occur in glyphosate systems.

WEED MANAGEMENT IN SOYBEANS USING FLUMIOXAZIN. Thomas T. Bauman, Michael D. White, and David E. Hillger, Professor, Research Associate, and Graduate Research Assistant, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Field trials were conducted from 1996 through 2001 at the Purdue Agronomy Research Center, West Lafayette, IN to determine flumioxazin's effectiveness in controlling weeds and its effect on soybean yield. A randomized complete block experimental design was used for all trials. Individual treatments consisted of four 30-inch rows that were 25 feet long and were replicated four times. All herbicide applications were made with a tractor-mounted sprayer. Flumioxazin applications were applied at 30 gallons per acre at a pressure of 30 psi. Weed control and crop injury ratings were taken before and after postemergence applications. The three rows of each plot were harvested to determine crop yield.

Flumioxazin was found to be an effective broadleaf weed component for weed control in Roundup Ready and non herbicide resistant soybeans. It also provided effective broadleaf control when applied as early preplant, burndown, and preemergnce treatments in no-till soybeans.

SOIL AND WEED MANAGEMENT INFLUENCES ON WEED POPULATIONS AND CROP YIELD IN A TOMATO/SOYBEAN ROTATION. Carlos D. Mayen and Stephen C. Weller, Graduate Research Assistant and Professor, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907.

A field experiment was established at Meig's Experimental Farm in Lafayette in the spring of 2001 to investigate the influence of various soil management techniques on soil seedbanks. The experiment involved the use of a fresh market tomato variety, 'Mountain Spring', and Round-up Ready soybean rotation. Soil management techniques involved conventional tillage, stale seedbed and a cover crop of winter rye. Weed management involved either a threshold based program or a zero threshold program where no weeds were allowed to reproduce. Measurements included weeds present in the soil seed bank at the beginning of the experiment, weed infestations during the season, crop yield and amounts of weed seed that returned to the soil through reproduction.

Seed emergence research indicates spring soil sample measurements (greenhouse germination) are an accurate measure of species abundance in the field plots during the season. Four weeks after crop planting (WAP), giant foxtail and prickly sida were most abundant, while other weeds observed in greenhouse germination studies were present to varying degrees. The exception was dandelion in rye plots. Apparently, rye traps dandelion seeds that are blown into the area. At 4 WAP, rye plots for tomato had more grass and dandelion than conventional and stale seedbed plots, but less total broadleaves. In soybeans, conventional plots had more foxtail than rye or stale seedbed, while prickly sida and broadleaf numbers (except dandelion) were similar. After herbicide applications (6 WAP), predominant weeds remaining in the soybean threshold plots were prickly sida and ivyleaf morninglory, dandelion in rye plots, and no foxtail. All weeds were reduced in size in the soybean plots. In tomato threshold plots, foxtail, prickly sida and ivyleaf morningglory were present. Rye plots had fewer ivyleaf morningglory, more dandelions and smaller prickly sida, while conventional contained less foxtails. Seed production varied between crops and treatments as well. There was no foxtail or ivyleaf morningglory seed production, and limited prickly sida seed production in the soybean threshold plots. For the tomato threshold plots, there was a heavy foxtail seed production for the stale and rye plots, while less morningglory seed production in rye plots and high prickly sida seed production in the stale and conventional. The effect of crop rotation in 2002 and the types and numbers of weeds present will begin to provide interesting insight into the influence of soil management effects on weed soil seedbank levels, return weed growth and interference in crop production. The weed management intensity had no effect on yield for both crops. Soybean yields were not affected by the soil management treatments, while tomatoes showed a reduction in the rye plots due to the later onset of flowering and fruiting.

DIMETHENAMID-P FOR WEED CONTROL IN POTATO. Bradley E. Fronning, George O. Kegode, and Mark G. Ciernia. Graduate Research Assistant, Assistant Professor, and Research Specialist, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Dimethenamid-p is currently being investigated for use as a herbicide for potato production. Experiments were conducted on irrigated fields near Dawson and Gwinner, ND, and a non-irrigated field near Crookston to compare weed control from dimethenamid-p alone and in tank-mixes to control from other labeled and non-labeled herbicides. Dimethenamid-p was applied at 740 g/ha and 1120 g/ha at Gwinner and Crookston. The lowest registered rate of dimethenamid in corn is 1040 g/ha. All treatments were applied preemergence (PRE) following final hilling of potato at all locations. Wild buckwheat, foxtail, and mild mustard control were evaluated at Dawson. The pattern was similar among treatments for control of wild buckwheat and wild mustard. Control was less than 60% for wild buckwheat and less than 68% for wild mustard when dimethenamid-p, pendimethalin, or rimsulfuron were applied alone 18 days after treatment (DAT) but control was over 90% when dimethenamid-p was tank-mixed with either pendimethalin or rimsulfuron. Weed control increased to greater than 90% between 18 and 74 DAT for all treatments. All treatments gave over 95% foxtail control. Dimethenamid-p at 740 and 1120 g/ha provided less control, 58 and 60%, respectively, of common lambsquarters than all other treatments 30 DAT at Gwinner. Common lambsquarters control 70 DAT was 95% with 1120 g/ha while control with 740 g/ha was only 78%. All other treatments provided greater than 90% control at both evaluations. Eastern black nightshade control with dimethenamid-p at both rates was 88%, less than from all other treatments at 30 DAT but control increased to 100% at 70 DAT. Dimethenamid-p and tank-mixes did not injure potato while flumioxazin and sulfentrazone caused injury. Wild oat control with dimethenamid-p at Crookston was 55% with 740 g/ha and 65% with 1120 g/ha at 20 DAT, and was 68 and 74%, respectively at 56 DAT. Control of foxtail with dimethenamid-p at Crookston was greater than 90% with both rates at 20 DAT, and averaged 78% at 56 DAT. Wild oat control generally improved between evaluations but foxtail control decreased. Dimethenamid-p did not injure potato at any location; early weed control was better when dimethenamid-p was tank-mixed with other herbicides. Irrigation appeared to improve weed control from all treatments.

WEED DIVERSITY IN GLYPHOSATE-TOLERANT SOYBEAN FROM MINNESOTA TO LOUISIANA. Julio Scursoni, Dean Peterson, Frank Forcella, Jeff Gunsolus, Roberto Benech Arnold, Mike Owen, Reid Smeda, Dick Oliver, and Roy Vidrine; University of Buenos Aires, Argentina, USDA-ARS, Morris, MN, University of Minnesota – St Paul, Iowa State University, University of Missouri, University of Arkansas, and Louisiana State University.

In Europe, especially, glyphosate-tolerant crop technology has elicited great concern. Some of this concern involves the perception that this new technology kills weeds so thoroughly that biodiversity will decrease relative to traditional forms of weed management. The concern with biodiversity involves not only the weeds, but also animals and microbes that depend upon weeds for food and cover. Our objectives were to examine trends in weed diversity (alpha, beta, and gamma diversity) along an environmental/longitudinal transect from Minnesota (5 sites), Iowa (3 sites), Missouri (2 sites), Arkansas (2 sites), to Louisiana (1 site); and a gradient of management intensity at each site that included the following treatments in glyphosate-tolerant soybean: (a) weedy check, (b) one-pass glyphosate, (c) two-pass glyphosate, (d) standard PRE plus glyphosate, and (e) standard PRE only or standard PRE plus standard POST, or standard POST only. Preliminary analyses of effective species richness ($e^{H'}$) indicate that rankings of weed diversity across treatments did not change substantially among locations. Diversity in the one-pass glyphosate treatment often was higher than that of weedy checks because the herbicide differentially suppressed dominant weed species. Standard PRE plus glyphosate and other standard treatments had comparably moderate diversities. Diversity in the two-pass glyphosate treatment typically was low: near zero in the North and substantially higher than zero in the South, but still usually lower than standard herbicide treatments. Bearing in mind that our data merit much more rigorous analyses, tentative results suggest that the impacts of glyphosate-tolerant crop technology on biodiversity will vary according to latitude and the number of glyphosate applications made in the soybean crop.

YIELD PENALTY DUE TO DELAYED WEED CONTROL IN CORN AND SOYBEAN. Stevan Z. Knezevic, Sean Evans, and Mike Mainz, Assistant Professor, Graduate Research Assistant, Research Technologist, Haskell Ag. Lab., University of Nebraska, Concord, NE, 68728-2828.

The two commonly asked questions by corn/soybean producers are: (1) how to time post emergence weed control and (2) how much is it going to cost if weed control is delayed. This is especially true for the cropping systems that utilize genetically modified crops.

The first question was addressed using a concept of critical period of weed controls (CPWC). CPWC is a period in the crop growth cycle during which weeds must be controlled to prevent yield losses. Research from University of Nebraska has determined that the length of such critical period was influenced by the cropping practices (eg. nitrogen (N) fertilizer and crop row spacing). Field studies conducted in eastern Nebraska determined the effects of three nitrogen rates on the CPWC in dry land corn and of three row spacings on the critical time for weed removal in dry land soybean. When data was averaged over years and locations, the study in corn concluded that CPWC ranged from V1-V11, V3-V10, V4-V9 and V6-V9 for N-rates of 0, 55, 110 and 210 kg/ha, respectively. Study in soybean suggested that critical time for weed removal coinsided with V3, V2 and V1 for soybean row spacing of &.5", 15" and 30", respectively.

In order to address the second question the yield loss data from the above studies were pooled over years-locations and related to the crop growth stage at the time of weed removal for both corn and soybean. The 5% yield loss was arbitrarily selected as a maximum acceptable loss . The two percent yield loss per every leaf stage of delay passed the critical time of weed removal was determined as the cost of delaying weed control in both corn and soybean. For example, the time (5% yield loss) to control weeds in 7.5 inch rows soybean was the V3 stage If weed control was delayed to the V4 (fourth trifoliate) the yield loss was 7%, costing a producer about 2 percent in yield losses due to prolonged competition from weeds. The same is true if weed control is delayed past the recommended critical time in other row spacings in soybean and various nitrogen levels in corn. This recommendation is applicable up to canopy closure in corn (about 11 fully developed leaves) and the R3 stage in soybean (beginning pod). If the weed control is delayed further than these indicated stages the yield losses will be much higher than suggested.

In terms of actual economic losses: (a) in corn, it will be about $4 per acre for every corn leaf stage of delay, assuming a price of $2 per bushel and a yield goal of 100 bushels per acre, and (b) in soybean, it will be about $5 per acre for every soybean leaf stage of delay, assuming a price of $5 bushel and a yield goal of 40 bushels per acre [106].

INFLUENCE OF HERBICIDE EFFICACY ON WEED SEED PRODUCTION. Andrew A. Schmidt* and William G. Johnson, Graduate Research Assistant and Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211.

Correct weed management decisions are imperative for growers to maximize the in-season yield potential and minimize future weed control problems. An incorrect decision may provide adequate crop yields or net returns, but may allow a few weeds to escape, produce seed and increase weed density in future years. The objective of this study was to determine if weed management decisions recommended by a weed management decision aid called WeedSOFT are related to increasing the soil's weed seed bank and to monitor the production of weed seed in two soybean row spacings. Standard conventional-till production practices were used to produce soybean in 38.1- and 76.2-cm rows. Weed management decisions were made when weeds were 5- to 10-cm tall, and soybean in the trifoliate growth stage. Similar treatments were applied in both row spacings for each year. Treatments included a weed-free check, weedy check, the recommendation that predicted the highest maximum yield, a treatment that will result in a 10% predicted yield reduction, and a 20% predicted yield reduction treatment. Weed population and seed counts were recorded in the fall. In both years the weedy checks contained a high density of common ragweed in both row spacing rows resulting in low numbers of seed from other weeds. The treatments that predicted the lowest maximum produced more weed seed. In 2000, there was a significant treatment by row spacing interaction with common waterhemp and common cocklebur. The 76.2-cm row treatments yielded approximately 100% more common waterhemp seed for most treatments. Approximately 100% more common cocklebur seed was produced in the 76.2-cm row treatments compared to the 38.1-cm rows except for bentazon + aciflourfen which produced less seed in 76.2-cm versus 38.1-cm rows. In 2000 the 38.1-cm treatments that predicted the highest yield generally resulted in 64% less seed of giant foxtail, common ragweed, ivyleaf morningglory, and common cocklebur than the 10% yield loss treatments. In 76.2-cm rows the treatments that predicted the highest yield generally resulted in 46% less seed of giant foxtail, common ragweed, common waterhemp, and ivyleaf morningglory than the 10% yield loss treatments. In 2001 there was no significant row spacing by treatment interactions but significant treatment differences. In 2001 the treatments that predicted the highest yield generally resulted in 95% less giant ragweed seed than the 10% yield reduction treatments.

ENVIRONMENTAL AND BIOLOGICAL FACTORS OF PERENNIAL WEED ESTABLISHMENT IN KENTUCKY NO-TILL FIELDS. Chad L. Brommer and William W. Witt. Graduate Research Assistant and Professor, Department of Agronomy, University of Kentucky, Lexington, KY 40546.

Conservation tillage practices have increased in row crops across the United States and no-till agriculture makes up 50% of the total row crop acreage in Kentucky. These tillage practices have many benefits to producers over the use of traditional tillage practices. There are problems associated with no-till fields in Kentucky and one of these is higher relative population of perennial weeds. The perennial weed population establishes primarily because of the lack of preplant tillage to disrupt the taproots of many broadleaf perennial weeds. Extension personnel and producers alike have noticed that perennial weed communities establish in similar areas in many different fields. These areas may include low or bottom portions of fields and in places where water would be more available. Producers also face the problem of having more acreage to manage to stay solvent. The added land area decreases the amount of time a producer can scout fields and make herbicide applications. With these observations in mind, a study was established to try and correlate the terrain attributes of no-till fields with occurrence of perennial weed populations.

One of the University of Kentucky's agricultural research farms, located in Calloway Co., was used as a site for these studies. A field was selected which had been in no-till production for several years and was currently planted in corn. Populations of hemp dogbane and trumpetcreeper were located and their position documented with a Starlink® GPS backpack unit. Digital elevation maps (DEM) were created using survey grade GPS reciever. From the DEM a series of hydrological and terrain maps were creates using ARCINFO. Data from these maps were used in conjunction with regression modeling to monitor the correlation between hydrology, terrain factors and perennial weed population. Terrain factors included slope gradient, profile curvature, plan curvature, tangential curvature, specific catchment area, upslope length, distance to local depression, elevation above local depression, and secondary terrain attributes of compound topographic index, stream power index, sediment transport capacity, and depression proximity index.

A correlation was drawn between the location of Trumpetcreeper and catchment area (0.40). All correlation values were at the 0.01 level. These values are indicators of run off and topography in a field. These correlations indicate that these weeds would be found in areas that are prone to run off and water collection areas in a clay loam soil with similar topographical characteristics. Future research will also include topsoil and subsoil characteristics and the relation to perennial weed occurrence. Also, each weed population within the study fields will be sampled for DNA to determine the mechanism of weed propagation.

GENE FLOW OF IMIDAZOLINONE RESISTANCE FROM CULTIVATED SUNFLOWER TO WILD RELATIVES. Rafael Massinga* and Kassim Al-Khatib, Research Associate and Associate Professor, Department of Agronomy, Kansas State University. Manhattan, KS 66506.

Field experiments were conducted to determine the rate of gene flow from the cultivated Imidazolinone (IMI)-resistant cultivated sunflower to two wild relative species: *Helianthus annuus* and *H. petiolaris* in two locations near Manhattan, Kansas in 2000. The wild species were established in greenhouse. At four to six leaf stages, seedlings were transplanted into concentric circles at distances of 2.5, 5, 15 and 30 m, surrounding a 10 m diameter circle planted with IMI-resistant cultivated sunflower. Harvested seed of *H. annuus* and *H. petiolaris* species was planted separately in the greenhouse. At two to four leaf stage plants were treated with 40 g ha $^{-1}$ of Imazamox to screen for herbicide resistance. Imazamox resistance was estimated 14 days after treatment by counting the number of plants that survived herbicide treatment. IMI-resistance was detected in both *H. petiolaris* and *H. annuus* 30 m from the source. However, IMI- resistance was higher in *H. petiolaris* than in *H. annuus*. In addition, resistance decreased with distance from source and was significantly affected by the predominant wind direction. These results indicate that the IMI-resistant cultivated sunflower can out cross with wild species and that can increase the possibility of IMI-resistance spread to susceptible populations.

SEEDLING MORTALITY AND BIOMASS REDUCTION OF THREE WEED SPECIES ESCAPING SOIL APPLIED HERBICIDE. Konanani B. Liphadzi and J. Anita Dille, Graduate Research assistant and Assistant Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

The use of bioeconomic models can be useful to growers in facilitating weed management decision making. Expected yield loss after application of control is often calculated based on a reduction in numbers of weeds, but the model assumes these survivors are as competitive as uncontrolled weeds. The result is an over estimate of expected yield loss. Understanding the real change in escaped weed competitiveness will improve predictions of yield loss and will lead to better economic decisions. A field experiment was conducted at Ashland Bottoms Agronomy Research Farm in 2001. The objective was to determine the effect of density on weed seedling mortality and biomass accumulation with and without exposure to pre-emergence herbicide. Corn was sown on May 15 in 0.76-m rows. Known quantities of velvetleaf, Palmer amaranth, and giant foxtail seed (20, 50, 100, 500 seed m^{-2}) were sown one day after corn planting into paired plots of 2 x 1 m^2 centered over one corn row. The experimental design was a randomized complete block with 5 replicates. Flumetsulam for velvetleaf or isoxaflutole for giant foxtail and Palmer amaranth was applied to one half of each pair, both at a rate of 0.039 kg a.i. ha^{-1}. Weed emergence and mortality data were collected at 6, 9, 13, 16, 26, 30, 33, 40, 43, 46, 51, and 55 days after planting (DAP). Cohorts of emergence were marked with colored wires to enable us to track survivors. Isoxaflutole delayed Palmer amaranth and giant foxtail emergence by seven days compared to no delay in velvetleaf emergence with flumatsulam. By 55 DAP, total giant foxtail, Palmer amaranth, and velvetleaf seedling emergence ranged from 3 – 100, 13 – 27, and 8 – 156 seedling m^{-2} respectively, across densities either with or without herbicide. Velvetleaf and giant foxtail seedling mortality was not affected by herbicide application but percent mortality was greater at low density. Mortality for giant foxtail decreased from 88% to 20%, 52% to 10% for Palmer amaranth, and 36% to 11% for velvetleaf, ranging from low density to high density, respectively. Palmer amaranth seedling mortality was not affected by either density or isoxaflutole. Biomass of herbicide treated plants was 65% lower than untreated plants for giant foxtail and 42% lower for velvetleaf. The combination of low density and herbicide treatment tended to have higher seedling mortality despite high variability in emergence numbers. Biomass accumulation of giant foxtail and velvetleaf were reduced by exposure to herbicide.

EVALUATION OF MEDIC SPP. AS A POTENTIAL COVER CROP IN CORN AND SOYBEANS.
Douglas D. Buhler, E. Charles Brummer, Keith A. Kohler*, and Lowell D. Sandell*, Chair and Professor, Associate Professor, Research Technician, and Agricultural Specialist, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824, Department of Agronomy, Iowa State University, Ames IA 50011, USDA-ARS National Soil Tilth Laboratory, Ames, IA 50011, and Department of Agronomy, Iowa State University, Ames, IA 50011.

Intercropping forage legumes with row crops such as corn has been proposed as a strategy to suppress weeds, control soil erosion, and contribute nitrogen to companion or subsequent crops. *Medic* species are annual legumes extensively used in Australian farming systems and as a cover crop in California. These species are relatively uncommon in the Midwest United States, yet possess many desirable attributes that would make them candidates for use as a cover crop in a corn/soybean rotation. Sufficient genetic variability exists within *Medic* species to allow for selection of plant types specifically suited for use as smother plants. The incorporation of a *Medic* cover crop may have the potential to aid in the correction of many significant environmental issues associated with current production practices. Developing symbiotic cover crop varieties that are compatible with primary crops may provide assistance in reducing soil erosion, reducing weed pressure, and providing soil nutrient and soil quality benefits.

The model for a successful cover crop is a plant that can produce dense vegetation quickly while not growing too tall to compete with the primary crop species. Another aspect of a successful cover crop is life cycle duration. Currently, many species that are considered viable options have a life cycle that is too long and results in excessive competition with the primary crop species. The numerous varieties of annual *Medic* species provide a wide breadth of plant growth capabilities that display a range of suitability for use as cover crops. For this reason a *Medic* nursery was established in Ames, IA in 1996 and 1997. This nursery of 25 *Medic* species, replicated four times was established to evaluate the suitability of a wide range of genetic material. Plant height, ground cover, life cycle length and a comprehensive relative suitability rating, on a 1 to 10 scale, were evaluated in this study.

There were wide ranges in each data parameter collected for these varieties each year. In 1996 plant height ranged from 5 to 34 cm, percent ground cover ranged from 34 to 90, and plant maturity ranged from fully vegetative to near 90% bloom. In 1997 plant height ranged from 3 to 27 cm, percent ground cover ranged from 49 to 89, and plant maturity ranged from full vegetative growth to 95% bloom. When comparing the comprehensive suitability ratings over years, the *Medic* varieties ‘polymorpha, p.i.283651’ (poly51) and ‘disciformis, p.i.487333’ (disci33) were among the highest rated each year. These two species had intermediate height, 21 and 13 cm for poly51 and 16 and 8 cm for disci33 in 1996 and 1997, respectively. The ground cover measurements for these species were not numerically the highest, but they did not differ significantly from the species with the highest mean in each year. Both varieties were among the furthest advanced in their life cycle at the time of data collection. In contrast, non-Medic varieties of annual forages included in the nursery (‘Mecca II’ and ‘Vernal’) were rated as the least suitable entries for each year. These varieties were characterized by tall plant height, 23 and 26 cm for ‘Mecca II’ and 24 and 24 cm for ‘Vernal’ in 1996 and 1997, while attaining % ground covers of 43 and 49 for ‘Mecca II’ and 39 and 58 for ‘Vernal’ in 1996 and 1997. At the time of data collection in 1996, both varieties displayed less than 10% bloom, while in 1997 both varieties were absent of bloom, and were continuing to compile vegetative growth.

Considering this wide range in genetic potential and the multiple morphological factors needed to achieve appropriate plant architecture, breeding compatible cover crops may be a difficult yet attainable goal.

OCCURRENCE OF COMMON MILKWEED IN IOWA. Dawn E. Refsell and Robert G. Hartzler, Graduate Research Assistant and Professor, Department of Agronomy, Iowa State University, Ames, IA 50011, and Douglas D. Buhler, Professor and Chair, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Larvae of monarch butterflies feed exclusively on members of the Asclepidaceae family. Common milkweed is the species most utilized by monarchs in the corn belt due to its abundance. The importance of common milkweed occurring in agricultural settings in the monarch life cycle is poorly understood. A survey was conducted from 1999 to 2001 to determine the relative abundance and stability of common milkweed in different vegetative habitats across Iowa. The initial survey in 1999 determined that approximately 50% of corn and soybean fields in Iowa were infested with common milkweed. In subsequent surveys in 2000 and 2001, row-crop fields infested with common milkweed declined to approximately 35%. In contrast, roadside right-of-ways infested with common milkweed were stable at approximately 75% from 1999 to 2001. The initial 1999 survey determined a high infestation frequency in land enrolled in the Conservation Reserve Program. A more extensive survey (100 sites) of undisturbed habitats in 2000 determined that 90% of these sites contained common milkweed. Swamp, honeyvine and eastern whorled milkweed were present in 5, 4 and 1% of the undisturbed habitats, respectively. These data, combined with information concerning land use patterns; can help determine the relative importance of milkweed occurring in agricultural land in the life cycle of the monarch.

ECOLOGICAL ASSESSMENT OF GLYPHOSATE TOLERANT CROPPING SYSTEMS. Curtis N. Bensch, Kassim Al-Khatib, and Charles W. Rice, Research Associate, Associate Professor and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

The exclusive use of postemergent herbicides in herbicide resistant crops can have an impact on the agroecosystem. Field studies were conducted in 2001 at Manhattan and Hays, Kansas to determine ecological benefits associated with glyphosate tolerant cropping systems under conventional and no-till practices. The experiments were established as a randomized complete block design with a split-plot (Hays) or strip-plot (Manhattan) arrangement with three replications. The main plot treatments consist of a conventional PRE herbicide, glyphosate early POST, or glyphosate late POST. The subplot tillage treatment is either conventional tillage or no-till. The crop rotation scheme for Manhattan is soybean/corn/soybean/corn over the four years of the study, and corn/fallow/wheat/corn rotation at Hays. Experimental data being taken to assess the ecological impact include data on soil nematodes, soil microbial biomass, substrate induced respiration of soil microbes, microbial community analysis using Biolog MicroPlates™, weed seed bank, soil moisture, residue cover, *Rhizobium* nodulation on soybean, *mycorrhiza* colonization of corn roots, water infiltration, and earthworm populations.

VARIABILITY IN WEEDINESS TRAITS OF COMMON COCKLEBUR. Mark R. Jeschke, James J. Wassom, and Patrick J. Tranel, Graduate Research Assistant, Postdoctoral Research Associate, and Assistant Professor, Department of Crop Sciences, Urbana, IL 61801.

Two studies were conducted to determine variability in weediness traits among accessions of common cocklebur collected from several sites across the United States. The first study compared the competitiveness of seven common cocklebur accessions by measuring their ability to reduce yield of soybean. Common cocklebur seedlings were started in a greenhouse and then transplanted to the field where they were planted at one meter intervals between 30 inch rows of soybean. In addition to non-destructive measurements taken throughout the growing season, measurements were taken on aboveground biomass of common cocklebur and soybean yield at the end of the season. The study was replicated over three years. Average soybean yield reductions for all seven accessions were 48%, 0%, and 20% in years one through three, respectively. Yield reduction rankings among accessions were consistent between the first and third year and showed a significant difference in yield reduction capability among common cocklebur accessions. Averaged over these two years, soybean yield reduction ranged from 25% to 42% among accessions.

The second study compared germination rates of several common cocklebur accessions. Field germination studies were conducted over the course of three years. Eighty burs of each of several accessions were planted in the fall and germinations counts were begun the following spring. Counts were taken twice a week and seedlings were removed as they were counted. Results showed major differences in germination rates among accessions, with first season germination ranging from 3% to 75%. Germination rates for accessions collected in the same state did not necessarily show a tendency to be similar. In addition to the field study, germination tests were conducted in a lab incubator.

EASTERN RED CEDAR CONTROL IN NEBRASKA PASTURE. Stevan Z. Knezevic, Assistant Professor, Haskell Ag. Lab., University of Nebraska, Concord, NE, 68728-2828, Adam Kantrovich, Instructor, Western Iowa Tech Community College, Sioux City, IO, 51102, and Robert Masters, A. Masters, Field Research Biologist, Dow AgroSciences, Lincoln, NE 68506.

Eastern redcedar is a common weed in pastures and rangeland throughout the United States. Field studies were conducted in 2001 at two locations in northeast Nebraska to determine the response of eastern redcedar to selected chemical and mechanical control methods. Herbicides were applied either broadcast or as high volume sprays to individual trees. Tree height was an important factor influencing level of chemical control, resulting in poorer control of taller trees. Eastern redcedar control was greatest when picloram was a component of the herbicide treatments either broadcast applied to trees or when individual trees were sprayed. Eastern redcedar control did not exceed 40% when triclopyr-containing treatments were applied.

Excellent control (> 85%) was provided by picloram at 187 g ae ha^{-1} + fluroxypyr at 187 g ae ha^{-1} (5 pints $acre^{-1}$), picloram at 184 g ae ha^{-1} + 2,4-D at 680 g ae ha^{-1} (6 pints $acre^{-1}$), picloram at 245 g ae ha^{-1} + 2,4-D at 908 g ae ha^{-1}(8 pints $acre^{-1}$), or picloram at 227 g ae ha^{-1} (2 pints $acre^{-1}$) broadcast applied to trees that were $\leq$ 30 cm in height. In contrast, these treatments provided poor control (< 50%) of trees that were > 60 cm in height.

Eastern redcedar control was excellent (> 85%) when individual trees were treated with picloram (0.66 lbs ae gal^{-1}) + fluroxypyr (0.66 lbs ae gal^{-1}), picloram (0.54 lbs ae gal^{-1})+ 2,4-D (2.0 lbs ae gal^{-1})and picloram (2.0 lbs ae gal^{-1}) applied in 1.5, 2.0, and 1.0 % (v/v) solutions, respectively.

CANADA THISTLE CONTROL WITH SPRING-APPLIED CLOPYRALID AND TRICLOPYR. Andrew T. Lee, Michael W. Marshall, J. D. Green, William W. Witt, Graduate Research Assistant, Research Specialist, Extension Specialist, and Professor, Department of Agronomy, University of Kentucky, Lexington, KY 40546.

Long-term canada thistle control in pastures and roadside right-of-ways has been inconsistent. 2,4-D, dicamba, and metsulfuron have been traditionally used to control or suppress canada thistle growth. Triclopyr plus clopyralid in a 3:1 mixture was recently labeled for roadside rights-of-ways and pastures. The target weeds for the herbicide were perennial broadleaves, including canada thistle. Field studies were conducted in 2001 at Lexington and Owingsville, KY to compare the initial burn-down and regrowth efficacy of clopyralid plus triclopyr at various rates to 2,4-D, dicamba, and metsulfuron. Triclopyr (0.80 kg/ha) plus clopyralid (0.27 kg/ha), triclopyr (1.28 kg/ha) plus clopyralid (0.43 kg/ha), 2,4-D (2.16 kg/ha), dicamba (1.70 kg/ha), and metsulfuron (0.01 kg/ha) were evaluated. All treatments were applied in June when canada thistle was pre-bud and 50 cm to 75 cm in height. Efficacy was rated on a percent control basis 4, 8, and 12 weeks after treatment (WAT). Immediately following the 8 WAT ratings, all plots were mowed to approximately 10 cm and regrowth was evaluated 12 WAT.
Data from both locations was combined because the location by treatment effect was not significant.
<u>4 WAT.</u> Percent control ranged from 71% to 85%. Triclopyr (1.28 kg/ha) plus clopyralid (0.43 kg/ha) at 85% and 2,4-D at 81% were greater than dicamba at 71% and metsulfuron at 71%.
<u>8 WAT.</u> Percent control ranged from 74% to 96%. Both rates of triclopyr plus clopyralid at 89% and 96% were statistically greater than all other treatments. Dicamba at 81% was statistically greater than metsulfuron at 74%.
<u>12WAT (Regrowth).</u> Control ranged from 25% to 71%. 2,4-D and both rates of triclopyr plus clopyralid were statistically greater than dicamba at 37% and metsulfuron at 26%.
In conclusion, increasing the rate of triclopyr plus clopyralid did not increase canada thistle control. However, triclopyr plus clopyralid did offer greater canada thistle control compared to 2,4-D (8 WAT), dicamba (4, 8, 12 WAT), and metsulfuron (4, 8, 12 WAT).

FALL HEBICIDE APPLICATIONS FOR TALL IRONWEED CONTROL IN GRASS PASTURE.
Michael W. Marshall, J.D. Green, David Ditsch, and Wade Turner, Research Specialist, Extension Professor, Associate Professor, and Extension Associate, Department of Agronomy, University of Kentucky, Lexington, KY 40546.

The grazing quality of a grass pasture can be substantially lowered by the presence of perennial broadleaves such as horsenettle (*Solanum carolinense*) and tall ironweed (*Vernonia gigantea*). Field studies were conducted at Robinson Experiment Substation in southeastern Kentucky to ascertain the efficacy of fall-applied herbicides on tall ironweed population and control. Experimental design consisted of a split-plot with red clover seeded and not seeded as the main plot and herbicide treatments as the sub-plot. The fall-applied treatments included 1) untreated check, 2) premix of 2,4-D + triclopyr (Crossbow) [1.1 kg ha^{-1} + 0.6 kg ha^{-1}], 3) premix of triclopyr + clopyralid (Redeem R&P) [0.42 kg ha^{-1} + 0.16 kg ha^{-1}], 4) premix of triclopyr + clopyralid (Redeem R&P) [0.62 kg ha^{-1} + 0.21 kg ha^{-1}], 5) premix of triclopyr + clopyralid (Redeem R&P) [0.42 kg ha^{-1} + 0.16 kg ha^{-1}] plus 2,4-D (1.1 kg ha^{-1}), and 6) dicamba (1.1 kg ha^{-1}). All treatments with the premix of triclopyr and clopyralid were applied with a nonionic surfactant (NIS) at 0.25% v/v. Herbicides were applied September 5, 2000 and red clover was seeded on March 1, 2001. Tall ironweed control ratings and density counts were taken on May 17, July 12, and September 21, 2001. Forage and tall ironweed yields were taken on May 17, July 25, and September 21, 2001. 2,4-D + triclopyr (1.1 kg ha^{-1} + 0.6 kg ha^{-1}) and triclopyr + clopyralid (0.42 kg ha^{-1} + 0.16 kg ha^{-1}) plus 2,4-D (1.1 kg ha^{-1}) provided the most consistent control the year following treatment. Triclopyr + clopyralid (0.42 kg ha^{-1} + 0.16 kg ha^{-1}) and triclopyr + clopyralid (0.62 kg ha^{-1} + 0.21 kg ha^{-1}) showed some loss of control, but overall level of control was good. Dicamba initially showed good control, however, control dropped off rapidly throughout the following summer. Tall ironweed populations nearly doubled the following summer in the untreated control plots. All treatments except dicamba showed a slight increase in tall ironweed populations, but the overall level of control was good to excellent. Dicamba treated populations were initially suppressed; however, regrowth was substantial and occurred rapidly the following year. Forage yield was slightly lowered by fall-applied herbicides; however, yield rebounded toward the end of the following growing season. Tall ironweed yields were consistent with both the control ratings and population data. In conclusion, tall ironweed populations were reduced with the use of fall-applied herbicides, however, the use of triclopyr containing products showed the greatest suppression the following year. Triclopyr, clopyralid, and dicamba treatments showed slight decrease in forage yield in the beginning of the growing season; however, the forage yields came back levels within the untreated yield. The use of fall-applied herbicides is only part of an integrated program, which includes mowing, proper soil pH and fertility, and controlled grazing program. In addition, reseeding is an important step in conjunction with fall-applied herbicide program because new weeds will emerge in bare areas left by the controlled weeds.

ABSORPTION AND TRANSLOCATION OF THREE HERBICIDES ON TWO STAGES OF SEEDLING SERICEA LESPEDEZA. Rodney A. Kunard, Walter H. Fick, and Kassim Al-Khatib, Assistant Scientist, Associate Professor, and Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Sericea lespedeza is an invasive weed of the central and southern Great Plains. Herbicides are commonly recommended for control of perennial plants, but often vary in effectiveness. To develop new best management practices for the control of sericea lespedeza, seedlings are being evaluated to determine if the effectiveness of herbicides can be improved. The objectives of this study were to compare the absorption and translocation of triclopyr, picloram, and metsulfuron on two different stages of seedling plants. Stage 1 plants were 7 to 15 cm tall, and stage 2 plants were 18 to 40 cm tall. Ten μl of a ^{14}C-labeled herbicide were placed on the 4th and 14th newest trifoliate leaf, for the respective stages. Plants were grown in a growth chamber and harvested at 1, 3, and 5 days for stage 1, and 1, 5, and 10 days for stage 2. The plants were partitioned into foliage above the treated leaf, treated leaf, foliage below the treated leaf, and the roots. Excess herbicide was rinsed from the treated leaf with distilled water. Plants were oxidized and the radioactivity determined using a liquid scintillation counter. Absorption of all three herbicides peaked 5 days after treatment (78, 51, and 70% for stage 1 and 78, 54, and 63% for stage 2 for triclopyr, picloram and metsulfuron, respectively). Translocation out of the treated leaf was greater for metsulfuron and picloram than for triclopyr in both stages. Distribution of metsulfuron and picloram to the foliage above and below the treated leaf was greater than triclopyr. These results suggest that spray coverage is important when using triclopyr, since it is not translocated as well as metsulfuron and picloram.

COMMON WATERHEMP RESISTANCE TO PROTOPORPHYRINOGEN OXIDASE (PPO)-INHIBITING HERBICIDES. Douglas E. Shoup and Kassim Al-Khatib, Graduate Research Assistant and Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Common waterhemp (*Amaranthus rudis*) is a troublesome weed throughout the Midwestern United States. A biotype of common waterhemp difficult to control with PPO-inhibiting herbicides was reported near Sabetha, KS in 2000. Greenhouse experiments were conducted to determine resistance, cross-resistance, and multiple resistance. Susceptible and resistant common waterhemp plants were grown in the greenhouse and seedlings were treated with 0.125, 0.25, 0.5, 1, 2, 4, and 8 times the use rates of acifluorfen, lactofen, fomesafen, sulfentrazone, imazethapyr, thifensulfuron, glyphosate, and paraquat. Herbicide rate required to inhibit growth by 40% (I_{40}) for the susceptible biotype were 8.8, 1.3, 19.8, and 26.6 for acifluorfen, lactofen, fomesafen, and sulfentrazone respectively, whereas I_{40} values for the resistant biotypes were 302.4, 106.9, 165.2, and 106.1 for acifluorfen, lactofen, fomesafen, and sulfentrazone respectively. In addition, the resistant biotype showed a high level of resistance to imazethapyr and thifensulfuron but not to glyphosate or paraquat. This study clearly showed that common waterhemp collected from the soybean field near Sabetha, KS has a high level for resistance to PPO-inhibiting herbicides.

EFFICACY, ABSORPTION, AND TRANSLOCATION OF VARIOUS GLYPHOSATE FORMULATIONS ON ANNUAL WEEDS. Jimmy D. Wait, Jianmei Li, William G. Johnson and Reid J. Smeda, Research Associate, Research Specialist, Assistant Professor, and Assistant Professor, University of Missouri, Columbia, MO 65211.

Numerous reports suggest differential activity of glyphosate on weed species based on formulation. The objective of a greenhouse experiment was to compare the control of velvetleaf with isopropylamine, diammonium trimethyl, and trimethylsulfonium salts of glyphosate. Three different rates of each formulation were applied with and without ammonium sulfate (AMS) and a non-ionic surfactant (NIS). Herbicides were applied on 10 to 15 cm plants with a spray volume of 93.5 L/ha. Visual ratings and plant fresh weights were taken 21 days after herbicide application. Results from this study indicate that the isopropylamine salt of glyphosate provided greater control of velvetleaf compared to the other formulations, and higher rates as well as addition of AMS and NIS improved control. Laboratory studies were conducted to determine if the salt formulation effected glyphosate uptake in velvetleaf during the first 72 hours following treatment. Up to 15 cm plants at the 3- to 5-leaf growth stage were pre-treated at 0.84 kg ae/ha with either the isopropylamine or diammonium trimethyl salt of glyphosate. Following treatment 20, 0.2 μL drops, of ^{14}C-glyphosate in each salt formulation were placed on the adaxial surface of the youngest fully expanded leaf of each respective plant. A total of 0.5 kBq was applied to each plant. Plants were harvested in 4 sections (treated leaf, above and below treated leaf, and roots) at 2, 6, 26, 50, and 74 hours following application of unlabeled glyphosate. The amount of herbicide absorbed was determined as ^{14}C by liquid scintillation spectrometry following combustion. Overall, of the ^{14}C-glyphosate absorbed into velvetleaf plants, there were no significant differences between formulations for all time periods. Glyphosate absorption continued up to 50 hours after application, with no significant differences between formulations. Distribution among plant tissue was also similar between formulations.

EFFICACY OF GLYPHOSATE AND ACCASE INHIBITOR HERBICIDES ON PRAIRIE CUPGRASS AND WINDMILLGRASS. D. Shane Hennigh, Kassim Al-Khatib and Phillip W. Stahlman. Graduate Research Assistant, Associate Professor, and Professor. Department of Agronomy, Kansas State University, Manhattan, KS 66504, KSU Agricultural Research Center, Hays, KS 67601.

Prairie cupgrass (*Eriochloa contracta*) and windmillgrass (*Chloris verticillata*) are a troublesome weed throughout western Kansas, Oklahoma, Nebraska, and Texas. Prairie cupgrass is an annual warm season grass that spreads through seed dispersal, whereas windmillgrass is a perennial warm season grass that spreads through seed dispersal and underground parts. While prairie cupgrass and windmillgrass can be controlled by tillage, management of both is difficult in no-till cropping systems. Glyphosate is widely used to control weeds in no-till systems, however glyphosate is inconsistent in controlling prairie cupgrass and windmillgrass. Glyphosate desiccates the foliage, but the plants generally recovered from the injury.

Greenhouse experiments were conducted to study the efficacy of glyphosate, clethodim, quizalofop, and sethoxydim on prairie cupgrass and windmillgrass at three different growth stages, including seedling, tiller, and flowering. Glyphosate at 1121g/ha caused 99, 67, and 77% injury to prairie cupgrass when applied at seedling, tiller, and flowering stages, respectively, and 89 and 99% injury to windmillgrass when applied at seedling and tiller growth stages. Prairie cupgrass and windmillgrass were susceptible to clethodim, quizalofop, and sethoxydim applied at 210, 70, and 350 g/ha, respectively, with total control of both species with these herbicides. A separate study was conducted to determine absorption and translocation of glyphosate in windmillgrass. Absorption of ^{14}C-glyphosate was more than 91%. However, glyphosate translocation out of the treated leaf was limited, 20, 9, and 18% of the absorbed glyphosate detected in the treated tiller, untreated tiller, and roots, respectively.

A field experiment was conducted in Hays, KS in 2001 to evaluate prairie cupgrass and windmillgrass response to herbicides in corn. A total of 23 treatments, were applied which consisted of 14 pre-emergence and 9 post-emergence treatments. Acetochlor + atrazine applied pre-emergence and sequential application of glyphosate gave the greatest control of both prairie cupgrass and windmillgrass.

QUINCLORAC EFFICACY AS AFFECTED BY SURFACTANTS, NITROGEN FERTILIZERS, AND pH. Zenon Woznica, John D. Nalewaja, and Calvin G. Messersmith, Visiting Scientist and Professors, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Quinclorac applied postemergence requires an adjuvant for efficacy. However, adjuvants may differ in effectiveness depending on chemistry, molecular size, hydrophilic/lipophilic properties, and other characteristics. Quinclorac is a quinolinecarboxylic acid and, similar to other acid-type herbicides, may be antagonized by salts present in the spray carrier.

Laboratory and greenhouse experiments (25±5 C, 50±10% RH) were conducted to determine quinclorac efficacy as influenced by nonionic surfactants, methylated seed oil (MSO), spray mixture pH, salts present in spray carrier, spray deposit characteristics, and absorption. Quinclorac at 105 g ai/ha was applied to 3-4 leaf green foxtail in 80 L/ha. Surfactants tested at 0.25% w/v were linear alcohol ethoxylates (LAE) with different chain lengths of 8 to 10, 12 to 14, and 16 to 18 carbons and 40, 60, and 80% ethoxylation. In a separate experiment, quinclorac was applied with a block copolymer nonionic surfactant (Pluronic® P-104) at 0.25% (w/v) and MSO at 1% (v/v) in distilled water, water containing sodium bicarbonate (500 mg Na^{+}/L) and calcium chloride (250 mg Ca^{2+}/L), and in two natural hard waters. Treatments were applied with and without 0.5% (w/v) ammonium sulfate, 0.5% (w/v) ammonium nitrate, 0.5% (w/v) urea, and 1% (v/v) 28% N (liquid ammonium nitrate/urea fertilizer). Quinclorac was applied in distilled water (unbuffered pH 2.6), distilled water plus 0.16% (v/v) triethanolamine (TEA) (buffered pH 7.3), and with various natural waters. Scanning electron micrographs (SEM) of quinclorac spray deposits with and without selected LAE surfactants were taken at 650X magnification 2-3 h after application. ^{14}C-quinclorac absorption was determined 24 h after application.

Quinclorac efficacy to green foxtail generally increased as alcohol chain length and percentage ethoxylation of LAE surfactants increased. Regardless of LAE surfactants, quinclorac phytotoxicity to green foxtail was nearly doubled from 40% to 76% when the spray mixture pH was increased from 2.6 to 7.3 by inclusion of TEA. Enhanced phytotoxicity and absorption by LAE surfactants related to close contact of the spray deposit to the cuticle and enhanced quinclorac solubility by high pH. Sodium and calcium ions strongly antagonized quinclorac efficacy when applied with a block copolymer surfactant and MSO. Ammonium sulfate or ammonium nitrate adjuvants were more effective than 28% N fertilizer in overcoming sodium and calcium antagonism of quinclorac. However, all nitrogen fertilizers equally overcame the antagonistic effect from ions present in natural well waters. These data demonstrate the potential for optimizing postemergence quinclorac efficacy by carefully selecting surfactant chemistry, surfactant hydrophilic/lipophilic balance, addition of proper nitrogen fertilizer, and by regulating pH of the spray mixture.

HERBICIDE APPLICATION TIMING FOR MAXIMUM BIENNIAL WORMWOOD CONTROL IN SOYBEAN. Bradley E. Fronning and George O. Kegode. Graduate Research Assistant and Assistant Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Biennial wormwood has recently become a problem for soybean producers in the northern Great Plains. Studies were conducted near Fargo, Leonard, and Wyndmere, ND, in 2000 and 2001 to determine the influence of herbicide application timing on biennial wormwood control in soybean. Herbicides were applied preemergence (PRE), preemergence followed by postemergence (PRE fb POST), and postemergence (POST). Biennial wormwood control was evaluated visually 28 and 42 d after treatment (DAT) for PRE treatments and 14 and 28 DAT for POST and PRE fb POST treatments. There were no differences in PRE treatments at Wyndmere or Fargo in 2000 or 2001 and at Leonard in 2000. At Leonard in 2001, sulfentrazone at 160 g/ha provided 65 and 48% control 28 and 42 DAT, respectively. In the PRE fb POST experiment, control was greater than 90% at Wyndmere and Fargo both years. At Leonard in 2001, sulfentrazone fb bentazon plus acifluorfen (2:1) (STORM®) provided 34 and 27% control 14 and 28 DAT, respectively.

The POST experiment compared split-applied and full-rate treatments. The first split treatment at all locations was applied to 1- to 2-trifoliolate leaf soybean when biennial wormwood was 2.5 to 5 cm tall at Wyndmere and Leonard and 1 to 2 cm tall at Fargo. The second split treatment was applied 12±1 days later. Full-rate single treatments were applied to 2- to 3-trifoliolate leaf soybean at all locations when biennial wormwood was 7 to 8 cm tall at Wyndmere, 5 to 6 cm tall at Leonard, and 2.5 cm tall at Fargo. All treatments at Fargo both years provided greater than 90% control of biennial wormwood 14 DAT, except the split-applied STORM® and full-rate lactofen treatments in 2000. Bentazon plus acifluorfen (4.5:1) (GALAXY®), both STORM® treatments, and lactofen at the full rate provided less than 90% control 28 DAT in 2000. In 2001, both lactofen treatments provided less than 90% control 28 DAT at Fargo. Bentazon split-applied at all locations provided more than 85% control of biennial wormwood 14 and 28 DAT.

Flumetsulam at 75 g/ha provided the best biennial wormwood control among PRE treatments at all locations, although the amount of control varied. Flumetsulam at 45 g/ha fb bentazon at 560 g/ha was the best PRE fb POST treatment at all locations. Bentazon split-applied overall was the most consistent treatment for biennial wormwood control when averaged over all experiments at all locations.

WINTER ANNUAL WEED CONTROL WITH FALL AND EARLY PREPLANT HERBICIDE APPLICATIONS. Ryan F. Hasty*, Christy L. Sprague, and Aaron G. Hager, Research Specialist, Assistant Professor, and Extension Specialist, University of Illinois, Urbana, IL 61801.

Fall-applied herbicide programs have gained market share in recent years for several reasons including winter annual weed control, applicator workload distribution, and field aesthetics. No-till field experiments were established in three regions of Illinois in the fall of 1999 and 2000 to represent Northern, Central, and Southern Illinois. The trial objectives include the following: 1) determine winter annual and early season summer annual weed control for compounds from several different chemical families, 2) compare fall applications with spring early preplant applications, and 3) determine if glyphosate plus 2,4-D is a necessary tank-mix component. Trials were set up in a randomized complete block design consisting of two application timings, mid-November for the fall timing and early April for the 30 day early preplant. Treatments included three residual herbicides applied at two rates: chlorimuron plus metribuzin(Canopy) at 160 and 368 g/ha, chlorimuron plus sulfentrazone (Canopy XL) at 99 and 269 g/ha, and metribuzin at 210 and 527 g/ha. Each treatment was applied with and without 2,4-D plus glyphosate at 280 and 628 g a.e./ha, respectively. A treatment of 2,4-D plus glyphosate was included in both timings as a standard for winter annual weed control without residual. Overall, Northern Illinois had fewer winter annual species and less weed pressure than other regions. At soybean planting common chickweed and shepherd's-purse control was >85% with all fall treatments with the exception of chlorimuron plus sulfentrazone. Early preplant applications needed the addition of 2,4-D plus glyphosate to control common chickweed. Giant ragweed control was not acceptable with any treatment. In Central Illinois, the addition of glyphosate plus 2,4-D significantly enhanced common chickweed control with fall applications of chlorimuron plus metribuzin, chlorimuron plus sulfentrazone, and metrizbuzin at 210 g/ha. All fall treatments provided excellent control of henbit. At both application timings, common lambsquarters control was greater than 90% with all treatments, except metribuzin and the tank-mixture glyphosate plus 2,4-D. Southern Illinois had the greatest pressure and diversity of winter annual weed species compared with the other regions of the state. At both application timings, wild mustard and butterweed control was excellent with chlorimuron plus metribuzin and chlorimuron plus sulfentrazone. The addition of glyphosate plus 2,4-D significantly enhanced common chickweed control compared with metribuzin alone. Purple deadnettle control was >88% with all treatments, except chlorimuron plus sulfentrazone at 99 g/ha applied early preplant. Overall, roughstalk bluegrass control was significantly higher with fall applications. Fall applications may provide adequate control of several winter annual weed species, however control of summer annual species is more consistent with spring herbicide applications.

WINTER ANNUAL WEED CONTROL WITH GLYPHOSATE. Brad A. Miller, Monsanto Company, St. Louis, MO 63167.

Field trials were conducted to determine the best application time for control of winter annual weeds with glyphosate (Roundup UltraMAX), and to determine if residual herbicides provided any advantages or disadvantages in weed control. Application timings included October, November, and December, 2000, and March, 2001. October applications included: 0.58 lbs ae/A Roundup UltraMAX; 0.75 lbs ae/A Roundup UltraMAX; 0.38 lbs ae/A Roundup UltraMAX + 0.5 lbs./A 2,4-D; 0.38 lbs ae/A Roundup UltraMAX + 0.188 lbs/A metribuzin; 0.14 lbs/A Canopy + 0.5 lbs/A 2,4-D; 0.14 lbs/A Canopy XL + 0.0047 lbs/A tribenuron; 0.05 lbs/A flumetsulam + 0.5 lbs/A 2,4-D; 0.016 lbs/A cloransulam + 0.38 lbs ae/A Roundup UltraMAX; 0.813 lbs/A Extreme; and, 0.75 lbs/A Backdraft. November, December, and March applications included: 0.58 lbs ae/A Roundup UltraMAX; 0.75 lbs ae/A Roundup UltraMAX; 0.38 lbs ae/A Roundup UltraMAX + 0.5 lbs./A 2,4-D; and, 0.38 lbs ae/A Roundup UltraMAX + 0.188 lbs/A metribuzin. Target winter annual weed species included: common chickweed; purple deadnettle; henbit; field pennycress; cressleaf groundsel; and, horseweed. Spring evaluations of Roundup UltraMAX treatments found that the October, November, and December applications provided greater control of purple deadnettle, henbit, cressleaf groundsel, and horseweed than the March application. Control of common chickweed was similar across Roundup UltraMAX application timings. Field pennycress control was greater with the March application, due to early spring field pennycress emergence. Following the October application of Roundup UltraMAX, a preplant burndown application in the spring of 2001 was required 55% to 73% of the time, depending upon rate. Following the October application treatments containing a residual herbicide component, a preplant burndown application in the spring of 2001 was required 27% to 73% of the time, varying by active ingredient. With all October applications, an in-crop application of Roundup UltraMAX was required on average one week after soybean planting, with the exception of 0.38 lbs. ae/A Roundup UltraMAX + 0.188 lbs./A metribuzin and 0.05 lbs./A flumetsulam + 0.5 lbs./A 2,4-D, which on average required a spring Roundup UltraMAX application to be applied at planting.

MANAGEMENT OF COMMON WATERHEMP IN NO-TILL GLYPHOSATE-RESISTANT CORN AND SOYBEAN. Christopher L. Schuster and Reid J. Smeda, Graduate Research Assistant and Assistant Professor, Agronomy Department, University of Missouri, Columbia, MO 65211.

Common waterhemp, a significant weed in Missouri crop production systems, has exhibited reduced control with glyphosate in some areas. No-till corn and soybean studies were established at two locations in northeast Missouri to evaluate the response of waterhemp to numerous labeled POST herbicides, as well as various glyphosate rates, 0.64 kg ae/ha to 1.26 kg ae/ha, and application timings, early post broadleaf (5 cm) and mid-post broadleaf (10 cm). Waterhemp response was evaluated visually at 2 and 5 weeks after treatment (WAT), and by recording plant biomass at 2, 6, and 10 WAT. Additionally, plant regrowth was recorded for plants surviving glyphosate. Visual ratings taken 2 WAT on plants treated with glyphosate showed >98 and >91% control of waterhemp at the Novelty (susceptible) and Monticello (suspected resistant) locations, respectively. By 5 WAT, visual ratings showed 100% control of waterhemp at the Novelty location and >98% control of waterhemp at the Monticello location. Visual ratings indicated no improvement in control by increasing the rate of glyphosate. There was no apparent distinction in biomass between plants harvested 2, 6, 10 WAT treatments where glyphosate was applied. Use of fomesafen and lactofen in soybean and dicamba and mesotrione in corn resulted in excellent waterhemp control (>98%). These results indicate that waterhemp is controlled with many herbicides, including glyphosate. Waterhemp control at Monticello was similar to that at Novelty, but a number of individual plants did survive applications of glyphosate. Waterhemp plants that survived glyphosate had no apical growing point, and regrowth occurred from the lowest axillary buds. Also, plants formed adventitious roots.

EASTERN BLACK NIGHTSHADE EMERGENCE AND CONTROL IN GLYPHOSATE RESISTANT SOYBEAN. Adrienne M. Rich and Karen A. Renner, Graduate Research Assistant and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Eastern black nightshade (*Solanum ptycanthum)* is a weed problem in soybean fields in the north central region of the U.S., including Michigan. Eastern black nightshade competes with soybean for moisture, nutrients, and light and reduces crop yield and quality. Faster canopy closure in narrow row soybean may decrease the competitive effect of many weed species by reducing the light available for the germination and growth of late emerging weeds. Eastern black nightshade is considered to be a shade tolerant weed, implying that emergence and growth may be less influenced by shading beneath the soybean canopy. Research was initiated in 2001 to determine if higher soybean populations and narrow soybean row spacing would reduce emergence and growth of eastern black nightshade. The need for a residual herbicide to stop late emerging eastern black nightshade following a glyphosate application in glyphosate resistant soybean was also determined.

The experiment was arranged in a split-split plot design with soybean row spacing as the main plot, population as the sub plot, and nightshade treatment as the sub-sub plot. Soybeans were planted May 14, 2001 in 76 cm and 19 cm rows and seeded in both row spacings at 432,000 and 308,600 seeds/ha. Eastern black nightshade treatments included glyphosate applied on June 22, 2001 when soybean was at the V3-V4 growth stage and eastern black nightshade was 2.5 cm tall, glyphosate + imazethypyr applied on June 22, 2001, and an untreated eastern black nightshade control. Emergence of eastern black nightshade was recorded weekly throughout the growing season. Light measurements were taken every 7 to 14 days perpendicular to the soybean rows to estimate soybean LAI. Eastern black nightshade density and biomass were measured in October. Soybeans were harvested on October 28, 2001 following hand removal of all eastern black nightshade plants one week prior to harvest.

Eastern black nightshade emergence in May and June was not influenced by soybean row spacing or population. Eastern black nightshade did not emerge following application of glyphosate or glyphosate + imazethapyr. Only 1.3 cm of rain fell in the 30 days following herbicide application, possibly reducing eastern black nightshade germination. LAI was greater in 76-cm rows planted at 432,000 seeds/ha compared to all other row spacings and populations in early July. From mid August to mid September LAI was greater in the 19 cm compared to 76 cm row spacing, with no difference in the LAI between soybean populations. Eastern black nightshade densities in October in the untreated controls were the same, regardless of soybean row spacing or population. However, eastern black nightshade biomass in 19- and 76-cm rows planted at the high population was reduced by 40% compared to biomass in the respective row spacing planted at the low population. Eastern black nightshade did not reduce soybean yield, regardless of soybean row spacing or population.

COMPARISON OF GLYPHOSTE BRANDS. Brady F. Kappler, Robert F. Klein, Stevan Z. Knezevic, Drew J. Lyon, Alex R. Martin, Frew W. Roeth, Gail A. Wicks. Extension Educator, Professor, Assistant Professor, Associate Professor, Professor, and Professor, Department of Agronomy University of Nebraska, Lincoln, NE 68583-0915.

Much attention has been given to the entry of other brands (trade names) of glyphosate into the market. Field studies were conducted in five locations across Nebraska to evaluate different brands of glyphosate herbicides. The study was conducted in glyphosate tolerant soybean at Clay Center, Concord, and Lincoln, Nebraska. The study was conducted in wheat stubble in North Platte and Sidney, Nebraska. Treatments of 0.42 kg ae/ha and 0.84 kg ae/ha of the following glyphosate products were applied; Roundup UltraMax, Roundup Ultra, Touchdown, Cornerstone, Glyphomax, Glyphomax Plus, and Roundup UltraDry. Most of the products represent the isopropylamine salt of glyphosate however, Touchdown is formulated as the diammonium salt of glyphosate and Roundup UltraDry is formulated as the mono-ammonium salt of glyphosate. All of the locations except Clay Center and North Platte evaluated treatments at 15 and 30 days after treatment (DAT). Clay Center and North Platte evaluated treatments at 10 and 30 dat. All sites were evaluated for percent control of both grass and broadleaf species.

In the glyphosate tolerant soybean treatment differences were small and varied slightly across the different trade names. Neither Lincoln, Concord, nor Clay Center had any largely significant differences in control at the 0.42 or 0.84 kg ae/ha rates or at the early and the 30 DAT ratings. At Sidney, in wheat stubble, there were once again very few significant differences between products at either rate. All four of these sites showed the expected increased control with the 0.84 kg/ha rate but the 0.42 kg/ha rate allowed us to approach a threshold level in which differences would be more easily detected.

In North Platte, wheat stubble showed significant differences in percent control of barnyardgrass. Roundup UltraDry at the 0.42 kg ae/ha rate provided significantly better barnyardgrass control than the other products at 10 DAT. At 30 days after treatment Roundup Ultra Dry and Roundup UltraMax provided significantly better weed control at the 0.42 kg ae/ha rate. At the 0.84 kg ae /ha Roundup UltraMax and Glyphomax provided significantly better control of barnyardgrass than the other glyphosate brands at both 10 and 30 DAT. However the 0.84 kg ae /ha treatment of Roundup UltraDry was not included at North Platte.

As a whole few differences were seen between different glyphosate brands in this study across the locations. However, with a difficult to control species, such as barndyardgrass, some differences became evident and showed that certain glyphosate products may provide better control of these difficult weeds like barnyardgrass. Still with species that are easily susceptible to glyphosate there seems to be little or no differences rather rate and environmental factors most likely play a larger role than brand name.

OVERCOMING MANAGANESE FERTILIZER ANTAGONISM OF GLYPHOSATE. Mark Bernards, Kurt D. Thelen, Don Penner, and Chad Lee, Graduate Research Assistant, Assistant Professor, Professor, and Extension Specialist, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Michigan soybean producers have observed antagonism of glyphosate when tank-mixed with foliar manganese (Mn) fertilizers. The objectives of this study were 1) to document glyphosate efficacy in tank-mixtures with different Mn-fertilizer formulations, both with and without various adjuvants, and 2) to evaluate glyphosate efficacy with different sequences and timings of separate Mn and glyphosate applications. Glyphosate was applied at 0.28 kg a.e. ha^{-1} to velvetleaf and giant foxtail in greenhouse bioassays and at 0.84 kg a.e. ha^{-1} in field trials. Manganese was applied at 9.3 L ha^{-1} (liquid formulations) or 7.84 kg ha^{-1} (powder formulations) in both field and greenhouse studies. Three Mn formulations (Mn-ethylaminoacetate, Mn-lignin sulfonate, and $MnSO_4$ monohydrate) antagonized glyphosate in the greenhouse (25-80% reduction in efficacy) and the field (20-50% reduction). Mn-EDTA (ethylenediaminetetraacetate) did not antagonize glyphosate, and in greenhouse studies enhanced glyphosate efficacy more than 50%. The adjuvants ammonium sulfate (AMS), EDTA, and citric acid each reduced some of the antagonism in tank-mixtures. The extent to which the antagonism was overcome depended upon the specific combination of Mn and adjuvant, but for most combinations a slight antagonism persisted (when compared to glyphosate + AMS). In greenhouse studies, ethylaminoacetate-Mn sprayed 3 days prior to glyphosate application antagonized glyphosate efficacy on velvetleaf but not giant foxtail. The degree of antagonism increased as the interval between applications decreased. However, Mn sprayed 1 day after glyphosate application had no effect on glyphosate efficacy. There was no antagonism on species present in field trials when Mn was sprayed prior to glyphosate.

SOYBEAN RESPONSE TO SIMULATED DRIFT OF ZA 1296. Scott A. Nolte, Julie M. Young, and Bryan G. Young, Graduate Research Assistant, Researcher, and Assistant Professor, Department of Plant, Soil, and General Agriculture, Southern Illinois University, Carbondale, IL 62966.

ZA 1296 is a broadleaf weed herbicide recently labeled for preemergence and postemergence use in field corn. Since ZA 1296 may be applied until corn is V8 or 76 cm in height, the potential exists for drift of ZA 1296 to emerged soybeans. Field studies were conducted in 2000 and 2001 at the Southern Illinois University Research Center in Belleville, IL to evaluate soybean injury and yield reduction from simulated drift of ZA 1296. ZA 1296 was applied at 1/100, 1/33, 1/10, 1/3, and 1 X the field use rate of 105 g ai/ha when soybeans were at the V1 stage of growth. The soybean variety evaluated in the field was ‘BT 386C’. All rates of ZA 1296 injured soybean plants at 7 and 14 DAT. Injury symptoms consisted of soybean stunting and leaf bleaching, necrosis, and distortion. Soybean injury was greatest at 14 DAT with 25 to 78% injury observed from ZA 1296. By 28 DAT, soybean injury was 31 and 66% from ZA 1296 at 1/3 and 1X, respectively, and less than 10% from ZA 1296 at 1/100, 1/33, and 1/10X. Soybean yield was reduced 11 and 22% by ZA 1296 at 1/3 and 1X, respectively. No reduction in soybean yield was observed from ZA 1296 at rates up to 1/10X. Regression analysis indicated that soybean injury from ZA 1296 at 28 DAT was the best predictor of yield loss (r^2=0.77) compared to injury evaluations at 7, 14, and 56 DAT.

Greenhouse studies were conducted to determine if soybean injury from ZA 1296 was influenced by soybean growth stage or variety. Soybean varieties included ‘BT 386C’, Asgrow ‘4602RR’, Pioneer ‘94B01’, and ‘LS 930375’. ZA 1296 was applied at a series of rates ranging from 1/1000 to 10X when soybean were at the VC, V1, and V2 stages of growth. All four soybean varieties were more sensitive to ZA 1296 at the VC growth stage compared to V1 and V2. GR_{50} values indicated that soybean tolerance to ZA 1296 increased as soybean growth stage increased with ‘BT 386C’, Pioneer ‘94B01’, and ‘LS 930375’. Asgrow ‘4602RR’ and Pioneer ‘94B01’ were 2 to 3 times more sensitive to ZA 1296 compared to ‘BT 386C’ at the V1 soybean growth stage. At the V2 soybean stage, Asgrow ‘4602RR’ was 3 to 5 times more sensitive to ZA 1296 compared to the other three varieties.

COMMON WATERHEMP INTERFERENCE IN CORN. Joseph C. Cordes and William G. Johnson, Graduate Research Assistant and Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211.

Field studies were conducted at Columbia, Novelty, and Albany, MO in 2001 on a Mexico silt loam, Putnam silt loam, and a Grundy silt loam respectively, to determine the effects of common waterhemp interference on corn growth, biomass, nitrogen accumulation, and yield. Ammonium nitrate (NH_4NO_3) fertilizer (180 kg ha^{-1}) was surface applied prior to planting. An EPOST (7-cm weeds) application of imazethapyr + imazapyr and bromoxynil was applied to control annual weeds except for waterhemp. Waterhemp was allowed to infest the experiment and treated at heights of 8, 15, 23, 31, 38 or 46 cm with dicamba + diflufenzopyr followed by hand hoeing 7 days after the herbicide treatment. These treatments were kept weed free after waterhemp removal. Corn and weed biomass, heights, fresh weights, and dry weights were collected at each waterhemp removal timing and at corn harvest from the Columbia site. The other two sites were utilized for yield data at different weed removal timings. Corn and waterhemp plant samples were analyzed for total nitrogen content. Corn leaf color was recorded with a SPAD^{tm} meter and soil water content measured with a portable time domain reflectometry probe (TDR) from the weed-free and weedy treatments at each removal timing. Corn yield responded differently to environments and waterhemp populations. Corn yield was not affected by waterhemp removal timing at Novelty, due to the low waterhemp populations (108/m^2). However, at Columbia corn yielded less than weed free checks when waterhemp was allowed to reach 31 cm or taller before removal (1065/m^2). The Albany site received excessive precipitation and waterhemp densities (115/m^2) were low thus competition for water and nitrogen was minimal and yield was not affected by removal timings. At the Columbia site waterhemp biomass contained 3.8% N when it was 8 cm tall, but only 2.0% N when it was 38 cm tall. Corn biomass contained 2.0% N and 1.3% N at these removal timings, respectively. On a per hectare basis, waterhemp accumulated 12.35 Kg of N by the time it was 8 cm tall and 44.46 Kg N by the time it was 38 cm tall. Corn biomass accumulated 38 and 93 Kg N at these waterhemp heights, respectively. This indicates that waterhemp is capable of accumulating N at a very rapid rate early in the growing season. Soil moisture was greater in the weed free plots compared to the weedy plots at Columbia when the waterhemp was 15, 23, 31, and 38 cm. Soil moisture at Novelty and Albany was not limiting throughout the season and differences between weedy and weed free treatments were only noticed at the 31-cm waterhemp removal timings. Corn leaf color as measured by the SPAD ^{tm} meter indicated that corn leaves in weedy plots contained less N compared to weed free treatments at the 38 and 46-cm removal timings at Columbia and Albany and the 23 and 31-cm removal timings at Novelty.

INFLUENCE OF TOTAL COMPETITIVE LOAD AFTER POST TREATMENT ON CORN YIELD.
Andrew A. Schmidt and William G. Johnson, Graduate Research Assistant and Assistant Professor University of Missouri, Columbia, MO 65211.

A computer decision aid called WeedSOFT is available for growers in Nebraska to assist in their weed management decisions. WeedSOFT has the potential of being another tool for growers and consultants in other states to use in their weed management decisions if it provides accurate efficacy and yield loss predictions. A regional project was initiated in 1999 to adopt WeedSOFT to other mid-western states. Two years of field trials were conducted in an attempt to evaluate the performance of the program. The objective of this presentation is to evaluate the yield loss prediction in corn in participating states. The herbicide treatments resulting in yield loss predictions of 20% and less were evaluated in Missouri, Illinois, Wisconsin, and Indiana corn trials to evaluate the accuracy of yield loss predictions at or near economic threshold levels. Conventional-till cultural practices were followed to produce corn in these areas. The experimental design of each site was a randomized complete block design with three or four replications. Initial weed counts and corn growth stage was recorded when weeds were 2.5- to 20.3-cm tall. Weed species and densities were entered into WeedSOFT to retrieve a list of allowable treatments ranked by predicted percent maximum yield. Treatments evaluated included a weed-free check, the recommendation that predicted the highest maximum yield, a treatment that will result in a 10% predicted yield reduction, the same treatment followed by cultivation 14 days after treatment, a treatment that will result in a 20% predicted yield reduction, and a cultivation treatment. Visual weed control ratings and weed counts for surviving weed species were collected 14 to 28 days after treatment. Harvest weed counts and yields were recorded in the fall. To evaluate the accuracy of the percent yield predictions, linear regression analysis was conducted on predicted versus actual yield loss values. A slope parameter estimate and coefficient of determination was calculated for each site-year, state, and four corn grain yield categories. A slope value of 1 would indicate a good correlation between predicted and actual yield loss values. The slope parameters ranged form 0.40 to 10.48 when the data were analyzed by site year. Sites that had treatments with consistent control between replications and low variability among weed densities at harvest time had a slope value between 0.6 to 0.81. When the data were analyzed by grain yield categories, sites that had low (<1419-kg/ha) or high (>2145-kg/ha) yields resulted in a slope value of 0.78 and 1.04, while the intermediate categories had a slope value of 2.31 to 3.57 respectively. Actual yield losses were generally greater than predicted yield losses in this version of the software. This would indicate that further modification to the efficacy database, competitive index assigned to the weeds, and yield loss function is warranted.

INFLUENCE OF VELVETLEAF DENSITY AND SOIL-APPLIED HERBICIDE ON DEVELOPMENT OF SIZE HIERARCHIES. J. Anita Dille, Assistant Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Sizes of individual plants in a population are generally far from uniform even when they emerge together. This inequality in plant size, or size hierarchy, has implications in the competitiveness, reproductive capacity, and mortality of individual plants, and of the plant population. The objective of this study was to determine the influence of velvetleaf density on development of size hierarchies with and without exposure to a soil-applied herbicide.

A greenhouse experiment was initiated on June 30, 2000 at Manhattan, KS. Black plastic flats (36- by 50- by 10-cm) were filled with clay loam soil. Velvetleaf seed were sown at equidistant spacings to obtain three densities equivalent to 115, 200 and 300 seedlings m^{-2} (21, 36, and 54 seedlings per flat). Five seed were sown at each spacing. Immediately after sowing, flats were either unsprayed or sprayed with a 0.023 kg ha^{-1} application of flumetsulam using a bench-type sprayer equipped with 80015 spray tips, 187 L ha^{-1} spray volume at 3.2 km per h. The experimental design was a randomized complete block with three replications. Individual plant height of the first emerged velvetleaf seedling at each location (others were removed) was measured 7, 14, 18, 21, 25, and 28 days after planting (DAP). The heights of all individuals were tracked throughout the experiment.

At 7 DAP, differences in average height are obvious between sprayed (11.2 mm) and unsprayed (22.7 mm) velvetleaf plants across densities. Flumetsulam did not impact velvetleaf germination and emergence, but does impact height immediately. The frequency distribution of sprayed individuals at 7 DAP was normal with a high mean frequency, while the distribution was also normal for unsprayed individuals, the distribution was wider around the mean frequency. This indicates greater variation in emerged and growing individuals. By 14 DAP, velvetleaf heights for both sprayed (22.6 mm) and unsprayed (46.8 mm) individuals were higher at the higher density compared to the two lower densities. The height differential between sprayed and unsprayed individuals was also increasing over time. At later DAP, the frequency distribution became skewed as expected, with few tall individuals and several short individuals. This size distribution could have an impact on the effectiveness of postemergence herbicide applications due to shading and competition.

GIANT RAGWEED EMERGENCE AND DEVELOPMENT UNDER DIFFERENT CROPPING SYSTEMS. Kurt D. Maertens, Christy L. Sprague, and Loyd M. Wax, Graduate Research Assistant, Assistant Professor, and Professor, University of Illinois, and USDA-ARS, Urbana, IL 61801.

In 2001, a field experiment was conducted at the University of Illinois Northern Illinois Agronomy Research Center in DeKalb. The objectives of this study were to: 1) evaluate giant ragweed emergence under three cropping systems, and 2) monitor growth and seed production of selected giant ragweed plants in these cropping systems. The study area was selected due to its natural heavy infestations of giant ragweed. The experiment was set up as a randomized complete block design with four replications of 6.1 m by 9.1 m plots. The cropping systems were soybeans, and corn planted in 76.2 cm rows, and no crop. Giant ragweed emergence was monitored weekly in two 1.0 m^2 fixed quadrats from April 10 through mid-July. After giant ragweed emergence, plots were kept weed-free, except for one plant per plot every two weeks to monitor growth and seed production. Giant ragweed emergence patterns were similar among the three cropping systems. Peak emergence occurred in the first two weeks and accounted for 50% of the total plants. However, giant ragweed emergence continued into July. Different cropping systems did not significantly affect the rate of giant ragweed emergence. Emergence time and cropping system did have an effect on giant ragweed's ability to compete. Competition with corn greatly suppressed dry weight and seed production of later emerging giant ragweed plants. Giant ragweed plants with no competition produced significantly more dry matter than plants grown in soybeans and corn. Emergence time had a significant affect on giant ragweed biomass for all three copping systems. However, emergence time did not have a significant affect on seed production when grown in soybeans. Collectively, this research shows that different cropping systems do not affect the rate of giant ragweed emergence, but have an affect on growth and seed production.

VARIATION IN MORPHOLOGYAND FATE OF GIANT RAGWEED SEED. Emilie E. Regnier, S. Kent Harrison, and Jerron T. Schmoll, Associate Professors and Research Associate, Department of Horticulture and Crop Science, Ohio State University, Columbus, OH 43210.

Experiments were conducted to quantify variation in seed (involucre) morphology among and within giant ragweed populations from different habitats and to determine if seed morphological features affected various seed fate processes. Variance component analysis of seed collected from 200 individual plants representing 8 populations indicated that 63% of the total variance in seed size and shape occurred among individual plants, 26% among populations, and only 12% within individual plants. Two-dimensional seed surface area and seed perimeter were greater, and seed perimeter:area ratio was smaller for giant ragweed populations growing in soybean fields compared to populations growing in undisturbed successional sites.

A seed burial study indicated that emergence of seedlings from large seeds (> 1.1 cm-diam) was more evenly distributed over burial depths ranging from 0 to 10 cm compared to small seed (<0.7 cm-diam), for which seedlings emerged primarily from the 0 to 5 cm burial depth. Giant ragweed seed viability after 4 years of burial was not influenced by seed size and averaged 1, 10, 23, and 38% for seeds buried 0, 5, 10, and 20 cm below the soil surface. Predation studies showed that mice exhibited size preference for giant ragweed seed by consuming small seed at approximately twice the rate at which they consumed large seed.

Additional experiments were conducted in which small and large giant ragweed seed were placed separately on the surface of a no-till soil within enclosed plots in order to monitor their respective fates when rodent, carabid, and bird access to the seed were denied. We observed that earthworms actively gathered and stored giant ragweed seed in their burrows at differential rates according to seed size. Approximately two weeks after seed deposition in the fall, earthworms had gathered 94% of the small seed into burrows, compared to 62% of large seed. The entire significance of seed polymorphism in giant ragweed fate and survival remains unclear; but thus far it appears that seed size alone plays a significant role in seedling emergence, seed predation, and seed burial processes.

Characteristics of Progeny from Crosses Between Waterhemp and Monoecious *Amaranthus* Species. Mary S. Gumz* and Stephen C. Weller, Graduate Research Assistant and Professor. Purdue University, West Lafayette, IN 47907.

Amaranthus species (the “pigweeds”) have become the most difficult weed to control in Indiana peppermint production fields and greatly reduce crop growth through competition. Pigweeds not only reduce crop growth, but also contaminate the peppermint hay and during hay distillation reduce the oil quality through imparting off-flavors and colors, rendering the oil unmarketable. Peppermint growers in Indiana have reported that in the past 10 years, pigweeds have not only become harder to control in their fields, but the incidence of escapes from labeled herbicide applications and the incidence of “off-type” pigweeds has increased. In addition, where the primary pigweed species present in Indiana were formerly redroot pigweed and powell amaranth, the incidence of waterhemps has increased dramatically. We have considered the possibility that hybridization between monoecious and dioecious *Amaranthus* species is occurring in Indiana and may account for the increased variability in phenotype and herbicide response observed in Indiana peppermint fields.

In these experiments, female waterhemp plants were fertilized with pollen from redroot pigweed, smooth pigweed, and powell amaranth. Viable F1 progeny was obtained from all three crosses. In all cases, the progeny were dioecious with near 1:1 male and female plants. The progeny were fertile and male F1 hybrids were backcrossed to female waterhemp plants and also crossed with female F1 hybrids. Progeny from the second set of crosses were all dioecious with near 1:1 male and female plants. Progeny from all three crosses showed waterhemp morphology.

Wild-type plants, offspring from the original crosses, and offspring from the backcrosses between the F1 males and waterhemp were sprayed with standard rates of terbacil, pyridate, and imazethapyr. All plants, wild types and hybrids, were susceptible to terbacil and pyridate. Only the monoecious wild type parents were susceptible to imazethapyr. All hybrids had the ALS resistance of the dioecious parent.

While evidence of field hybridization of *Amaranthus* species is limited, hybridization is possible. Although, peppermint growers are currently able to control mixed dioecious and monoecious *Amaranthus* populations with terbacil and pyridate, growers in other crops will need to reevaluate herbicide use in controlling mixed *Amaranthus* populations.

ADJUVANT AND ADJUVANT COMPONENTS INFLUENCE ON PERFORMANCE OF VARIOUS HERBICIDES. Gregory K. Dahl and Joe V. Gednalske, Research Coordinator and Manager Product Development and Registration, Agriliance LLC, St. Paul, MN 55164.

Separate studies were conducted in the field where nicosulfuron, rimsulfuron + nicosulfuron, imazimox, clethodim, mesotrione, and AEF 130360 were applied at reduced rates with oil type adjuvants. The adjuvants compared included a standard crop oil concentrate containing 17% emulsifier and 83% paraffinic oil applied at 1% v/v, several high load crop oil concentrates containing 40% emulsifier and 60% paraffinic oil applied at 0.5% v/v, methylated seed oils applied at 1% v/v, and versions of a modified crop oil concentrate adjuvant system that includes high fructose corn syrup.

Herbicide performance with high load crop oil concentrate adjuvants was applied at 0.5% v/v was generally similar to those herbicides applied with a standard 17% crop oil concentrate at 1% v/v. Herbicide performance applied with modified crop oil concentrates containing high fructose corn syrup at 0.5% v/v was similar to herbicides applied with 17% crop oil concentrate at 1% v/v. Performance of herbicides applied with methylated soybean oil at 1% v/v was greater than or equal to herbicides applied with the crop oil concentrates. Satisfactory herbicide performance was achieved by substitution of standard crop oil concentrates with high load crop oil concentrates or crop oil concentrates using high fructose corn syrup.

Separate studies were conducted where glyphosate and clethodim were applied at reduced rates alone or with ammonium sulfate, emulsifiers, high fructose corn syrup, or combinations of these components.

Herbicide performance was increased by the addition of ammonium sulfate, high fructose corn syrup, and emulsifiers alone and in combination. Performance of herbicides with adjuvant component combinations was greater than or equal to performance of herbicides with individual components.

SPRAY VOLUME, AMMONIUM SULFATE, AND FORMULATION INFLUENCE GLYPHOSATE EFFICACY. Brad K. Ramsdale and Calvin G. Messersmith, Postdoctoral Research Fellow and Professor, Department of Plant Sciences, North Dakota State University, Fargo, 58105.

A series of field experiments were conducted to examine the influence of spray volume, ammonium sulfate (AMS) concentration, and herbicide formulation on glyphosate efficacy. Details of experimental methods and environmental conditions at treatment are available in individual reports published in the North Central Weed Science Society Research Reports, Vol. 56 and 58.

Overall, glyphosate (Rodeo) efficacy was greater with 0.5% w/v AMS (4 lb/100 gal water) than with glyphosate alone, regardless of water source. Glyphosate plus 0.5% w/v AMS was equally effective as glyphosate plus 1% or 2% w/v AMS when applied with water containing low levels of antagonistic salts, and occasionally glyphosate plus 2% w/v AMS was less effective than glyphosate with 0.5% or 1% w/v AMS. Perhaps excess AMS in the spray deposit limited glyphosate uptake. Regardless, 0.5% w/v AMS was sufficient to maximize glyphosate efficacy in spray water without antagonistic salts. Glyphosate applied with antagonistic well water occasionally became more effective as AMS concentration increased, but the response was not consistent and did not relate to glyphosate rate.

Glyphosate (Roundup Ultra) at 0.06 lb/A applied in 2.5 or 5 gal/A spray volume provided equal or greater grass control than glyphosate at 0.12 lb/A applied in 10 or 20 gal/A. Similarly, glyphosate at 0.03 lb/A applied in 2.5 or 5 gal/A provided equal or greater grass control than glyphosate at 0.06 lb/A applied in 10 or 20 gal/A spray volume. The addition of 0.5% v/v nonionic surfactant (NIS) enhanced glyphosate efficacy regardless of spray volume, although the greatest enhancement was when glyphosate was applied in 10 or 20 gal/A. The amount of NIS in the formulation at 10 or 20 gal/A may have been insufficient to maximize efficacy of glyphosate at reduced rates.

Glyphosate (Roundup UltraMax) at 0.19 lb/A applied in 5 gal/A spray volume increased quackgrass control by up to 45% compared to application in 20 gal/A. Glyphosate at 0.19 lb/A applied in 5 gal/A provided similar quackgrass control to glyphosate at 0.38 lb/A applied in 20 gal/A spray volume. Likewise, glyphosate at 0.095 lb/A applied in 5 gal/A spray volume provided similar control to glyphosate at 0.19 lb/A applied in 20 gal/A. The addition of 0.5% NIS generally did not enhance quackgrass control by glyphosate at 5, 10, or 20 gal/A spray volumes. Thus, the decrease in glyphosate efficacy as spray volume increased was likely associated with decreased herbicide concentration rather than insufficient adjuvant.

Roundup Ultra, Glyphomax Plus, Glyfos X-tra, Touchdown Pro, and Roundup UltraDry generally provided similar control with no consistent differences when applied in 2.5 or 10 gal/A spray volume and with or without AMS at 8.5 lb/100 gal. AMS usually enhanced glyphosate efficacy regardless of spray volume or formulation. Species control by glyphosate as Roundup Custom plus NIS was not influenced by spray volume. Roundup Ultra, Glyphomax Plus, Glyfos X-tra, Touchdown Pro, and Roundup Ultra Dry applied alone were all more effective in 2.5 than 10 gal/A spray volume. The amount of adjuvant in the formulation at 10 gal/A may have been insufficient to maximize efficacy of glyphosate applied at 0.06 lb/A.

EVALUATION OF NOVEL ADJUVANT BLENDS WITH GLYPHOSATE. Todd R. Wehking and Kirk A. Howatt, Graduate Research Assistant and Assistant Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Studies were established in the greenhouse to evaluate the ability of six novel adjuvant blends to overcome hard-water antagonism and to control wheat and sunflower bioassay species. Treatments were applied to wheat at the two-and-a-half leaf stage and to sunflower at the four-leaf stage. Water used as the spray carrier was of three qualities: distilled, moderately hard, and hard. Six novel adjuvant blends were compared to three commercial adjuvants including Activator 90, Class ActII, and Class Act New Generation in greenhouse experiments. Glyphosate at 100 g ae/ha and adjuvants were applied with and without spray-grade ammonium sulfate (AMS) to determine their ability to overcome hard-water antagonism. Control of the assay species was based on visual evaluations 7 and 14 d after treatment (DAT) and dry weights 14 DAT.

Control of wheat and sunflower 7 DAT by glyphosate applied in distilled water was comparable with both the novel and commercial adjuvants. Glyphosate and adjuvant combinations applied in hard water without AMS offered 1 to 11% control. Glyphosate applied with Class ActII and Class Act New Generation in hard water provided 24 and 36% control, respectively. Wheat biomass was lowest across all three water qualities when Class ActII and Class Act New Generation were included in the spray mixture. The addition of AMS at 2% (w/v) to spray mixture containing glyphosate and a non-AMS adjuvant improved control to 21 to 31%, which was similar to commercial blends that contained AMS. Sunflower control 14 DAT was significantly higher when Class ActII and Class Act New Generation (83 and 90%, respectively) were added to hard water than when other adjuvant combinations were applied without AMS. Sunflower biomass was lowest across all three water qualities when Class ActII and Class Act New Generation were included in the spray mixture.

INFLUENCE OF NOZZLE TYPE AND SPRAY PRESSURE ON DROPLET SIZE. Robert E. Wolf, Cathy L. Minihan and Dallas E. Peterson, Extension Specialist, Biological and Agricultural Engineering, Graduate Research Assistant and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

More information about how to use the latest nozzle technologies to apply herbicides for postemergence control of grasses and broadleaves is paramount for achieving optimum control of the undesired pests. The complexity of the postemergence application process is exemplified as recent nozzle technology is placing an increased emphasis on keeping the drift potential at a minimum. Nozzles are being designed that will reduce the variability of the drop size spectrum thus improving the quality of spray for a given nozzle size and pressure.

This study was designed to measure the droplet characteristics of venturi, (AI); extended range, (XR); turbo, (TT); and Combo-Jet, (DR) flat-fan spray tips. The AI, XR, and TT are Spraying Systems/TeeJet tips and the DR tip is from Wilger. The four tips were compared at 47 and 94 L/ha. The spray pressures used were 173 kPa for the extended range flat-fan, 242 kPa for the Turbo and Combo-Jet flat-fans, and 345 kPa for the AI flat-fan. The nozzle angle and orifice sizes used were 110015 and 11003 for the XR and TT flat-fans, 110015 and 110025 for the AI flat-fans, and 80015 and 8003 for the Combo-Jet DR flat-fans. The 015 and 025/03 orifice sizes respectively determined the 47 and 94 L/ha application volumes. The applications were made with a tractor plot-sprayer equipped with a 3 m rear mounted boom. Nozzles were spaced at 76 cm and located 51 cm above the target. Water sensitive cards were placed under the spray boom to collect the droplet data. The study was comprised of two experiments with 16 treatments each. Three cards per treatment over two replications per experiment were summarized representing 64 cards for each position and a total of 192 cards. DropletScan software was used to analyze the cards.

The volume median diameter (VMD, 50%) was measured for each tip. The VMD means for the XR, TT, DR, and AI were 405, 450, 515, and 559 microns respectively. Each tip produces a unique droplet spectrum and progression from smaller to larger was as expected.

An important statistic for indicating drift potential is the number of droplets that are 200 microns or less in size. The means for this statistic and each tip were compared. The extended range flat-fan tip at 173 kPa had 746 droplets that were less than 200 microns. The turbo flat-fan tip at 242 kPa produced 398 droplets under 200 microns. The Combo-Jet flat-fan tip at 242 kPa produced 129 droplets under 200 microns and the air-induction flat-fan at 345 kPa produced the least number of droplets under 200 microns at 104. The data indicate the extended range flat-fan tips produce significantly more driftable droplets even when used at the lower pressure. The turbo flat-fan produced about one half the number of the extended range and over double the amount of the Combo-Jet DR and the AI venturi nozzles. The DR and AI tips were closely matched for number produced. However, even at 345 kPa the AI tip produced the least amount of droplets subject to drift.

As evidenced in this study, even when used at the recommended pressures the four tips compared in this study produced significantly different VMD's and all had different drift potential.

COMBINED INFLUENCE OF DRIFT REDUCTION NOZZLES AND AGENTS ON GLYPHOSATE EFFICACY. John F. Fietsam and Bryan G. Young, Graduate Research Assistant and Assistant Professor, Department of Plant, Soil, and General Agriculture, Southern Illinois University, Carbondale, IL 62901.

Two identical field studies were conducted in 2001 to determine the combined influence of drift reduction nozzles and agents on glyphosate efficacy in glyphosate-resistant soybean. Glyphosate was applied at 35 g ae/ha alone and in combination with two drift reduction agents, 30% polyacrylamide (PA) and hydroxypropyl guar (HPG). PA and HPG were applied at two rates of 150 and 300 mg/L and 300 and 600 mg/L, respectively. Each treatment was applied through one of four 110015 nozzle types (XR TeeJet, Turbo TeeJet, AI TeeJet, and DG TeeJet) at a spray volume of 94 L/ha.

In the first study, control of giant foxtail with glyphosate at 28 days after treatment (DAT) was reduced with the addition of HPG compared to PA and no agent with all nozzle types. Applying the low rate of PA and HPG did not reduce giant foxtail control at 28 DAT with any nozzle in the second study. However, the high rate of PA with the Turbo TeeJet and AI TeeJet nozzles as well as the high rate of HPG with AI TeeJet nozzles reduced control of giant foxtail compared to glyphosate with no agent. Control of common waterhemp was reduced by up to 22% with HPG applied with all rate and nozzle combinations. The addition of PA to glyphosate at any rate reduced control of common waterhemp with the DG and Turbo TeeJet nozzles. Applying the high rate of PA and HPG with the AI TeeJet nozzles resulted in at least a 12% reduction in control of common cocklebur at 28 DAT. Similarly, velvetleaf control 28 DAT was reduced when PA was combined with AI TeeJet nozzles. No reduction in control of common ragweed or ivyleaf morningglory was observed with any drift reduction agent at 28 DAT. However, control of these weeds was reduced when glyphosate was applied with DG or AI TeeJet nozzles compared to Turbo TeeJet nozzles. The combination of HPG and XR TeeJet nozzles reduced control of yellow nutsedge at 28 DAT compared to treatments of the same nozzle type containing PA or no agent. In contrast, the addition of PA and HPG in combination with DG TeeJet nozzles significantly increased yellow nutsedge control, which may be related to spray retention.

Soybean yield in the first study was reduced with the use of AI TeeJet nozzles due to poor control of common waterhemp. Treatments with the high rate of HPG consistently yielded less than those with no agent with all nozzle types. Yield in the second study was generally higher, which was likely related to the abscence of common waterhemp pressure from the study. Results of these studies indicate glyphosate efficacy is influenced by nozzle type, the rate and type of drift reduction agent, and the combination of each with the most pronounced impact on control of common waterhemp.

REMOTE SENSING: A NEW APPROACH TO VARIABLE RATE HERBICIDE APPLICATION. David J. Alderks and Christy L. Sprague, Loyd M. Wax and Kenneth Copenhaver. Graduate Research Assistant and Assistant Professor, Department of Crop Science, USDA-ARS, University of Illinois, Urbana, IL 61801, and ITD/Spectral Visions, Champaign, IL 61801.

In 2000, a field scale study was set up in a producer's soybean field near Champaign, Illinois. The objective was to determine if remote sensing could be used to detect different weed populations in the field and develop a variable rate herbicide application map from the resulting images. Prior to herbicide application, weed densities and heights were collected from 66 4-m^2 random points for ground truth and accuracy assessment. Airborne multi-spectral imagery was taken at a 4-m^2 resolution and merged with 1-m^2 panchromatic imagery to simulate pan-shaped IKONOS satellite data. An unsupervised classification on the imagery was preformed to generate a herbicide application map. Ground truth data and class statistics were used to group the weed infestations into three classes, low, medium, and high. Three glyphosate rates of 33%, 67%, and 100% of the labeled use rate were assigned to the low, medium, and high classes, respectively. An accuracy assessment indicated the classification was very successful at delineating the weed infestations. Variable rate applications based on the herbicide application map were compared with a full application rate of glyphosate for weed control. Results from these plots indicated that there were no differences in weed control and yield between the two application methods.

SOIL FACTOR EFFECTS ON ISOXAFLUTOLE PLUS FLUFENACET PHYTOTOXICITY IN TWO CORN HYBRIDS. Lawrence E. Steckel*, F. W. Simmons, and Christy L. Sprague, Graduate Research Assistant, Associate Professor, and Assistant Professor, Crop Sciences Department, University of Illinois, Urbana, IL 61801.

The premixture of isoxaflutole and flufenacet is used for selective broadleaf and grass weed control in corn. Recent studies have suggested that observed corn response to isoxaflutole may be affected by soil properties. In 2000 and 2001, field experiments were conducted at three of the University of Illinois Crop Sciences Research and Extension Centers. The objectives of these studies were to: (1) evaluate what affect soil properties (i.e. pH, organic matter, and texture) have on isoxaflutole plus flufenacet injury to corn, and (2) determine if these effects vary between two corn hybrids. Soil types were a Flanagan silt loam with 3.6% O.M. at Urbana, a Drummer silt loam with 4.5 % O.M. at DeKalb, and a Cisne silt loam with 2.0% O.M. at Brownstown. These studies were conducted at locations where soil pH was adjusted in individual plots to encompass a range of <6.0 to > 7.5. Isoxaflutole plus flufenacet premixture rates were based on the recommended labeled rate for a particular soil type. Herbicide treatments consisted of the labeled rate, 2X, and 4X the labeled rate of the premixture. Additional treatments included the labeled and 2X the labeled rate of the premixture, tank-mixed with 454 g ha^{-1} of atrazine. Atrazine plus *S*-metolachlor at 1.3 kg ha^{-1} was used as a control. The corn hybrids evaluated were Garst 8600 and Garst 8366. Stand counts and corn injury ratings were taken 6 weeks after planting and corn grain yield was measured in the fall. At Urbana, the premixture of isoxaflutole plus flufenacet did not significantly injure corn, reduce population or yield, except when the 2X rate of the premixture was tank-mixed with atrazine. At DeKalb, there were no differences in corn yield with Garst 8600, even though corn populations were reduced and corn injury was significant at the 2X and 4X rates of the premixture and the 2X rate of the premixture tank-mixed with atrazine. However with Garst 8366, 4X the premixture and 2X the premixture tank-mixed with atrazine reduced corn yield. At Brownstown, Garst 8366 yield was reduced with all treatments containing isoxaflutole plus flufenacet, except for the labeled rate of the premixture tank-mixed with atrazine. Yield of Garst 8600 was also reduced with 2X and 4X rates of isoxaflutole plus flufenacet. From these studies, Garst 8366 appears to be more sensitive to isoxaflutole plus flufenacet than Garst 8600. In addition, the frequencies of corn injury and yield reductions were greater on soils with less organic matter.

ENVIRONMENTAL IMPACTS OF TRANSGENIC CROPS. Richard S. Fawcett, President, Fawcett Consulting, Huxley, IA 50124.

Because benefits to farmers have driven the adoption of transgenic crops, planting of these crops is sometimes perceived as having little or no benefit to the rest of society. To the contrary, numerous studies have documented environmental and human health benefits from the use of these crops. Some benefits result from reductions in pesticide applications, reducing impacts on beneficial insects, aquatic ecosystems, and wildlife. A 10% decline in the overall rate of soybean herbicide use occurred during the period 1996-1998, which has been attributed to adoption of glyphosate-tolerant soybeans. Cotton insecticide use has declined dramatically with the adoption of Bt-cotton. From 2.0 to 5.5 fewer insecticide applications per year are made to Bt-cotton compared to conventional cotton, resulting in an annual reduction of over one million kg of insecticide active ingredient. Other benefits occur as transgenic herbicide-tolerant crops facilitate conversion from tillage-intensive and erosive crop production systems to conservation tillage systems. During the period 1996-2001, following the introduction of glyphosate-tolerant soybeans, no-till soybean acres more than doubled to 49% of total soybean acres. When soybean growers were asked in an American Soybean Association survey which factors had the greatest impact on increasing the adoption of reduced tillage or no-till soybeans, 54% cited the introduction of glyphosate-tolerant soybeans, 15% improvements in planting equipment, and 12% availability of over the top or in crop herbicides. Glyphosate-tolerant soybeans have been adopted more rapidly by no-till producers than by conventional tillage producers. In 2000, 74.5% of no-till soybeans were glyphosate-tolerant, compared to 52.9% of conventional tillage soybeans. Bt-corn not only reduces yield losses due to insects, but reduces fungal infections facilitated by insect feeding. Reductions in fungal mycotoxins, such as fumonisins, have been documented in Bt-corn, reducing human exposure to these highly toxic compounds.

GLYPHOSATE CAN REDUCE GROUND COVER OF TALL FESCUE GRASS WATERWAYS USED FOR EROSION CONTROL. William W. Donald, Research Agronomist, USDA Agricultural Research Service, 269 Agricultural Engineering Building, University of Missouri, Columbia, MO 65211.

Recently, glyphosate use for controlling weeds has increased in the Corn Belt because of widespread adoption of glyphosate-resistant soybean and field corn varieties and no-tillage production practices on highly erodible land. However, glyphosate drift or over-spraying may damage tall fescue planted for ground cover in grassed waterways or field borders, reducing its effectiveness for trapping sediment and minimizing soil erosion. The long-term impact of glyphosate on tall fescue ground cover was evaluated at two sites in central Missouri. Glyphosate [Roundup Ultra] was applied in mid-May to well-established tall fescue sod waterways at rates of 0 (untreated check), 0.14, 0.28, 0.56, 0.84, 1.12, 1.68 and 2.24 kg ai/ha plus ammonium sulfate solution at 2% (by volume) either with or without mowing four weeks before spraying to simulate spring grazing. Live tall fescue cover, dead tall fescue cover, broadleaf weed cover, total live + dead ground cover, and bare soil were measured from digital photographs and were used to estimate soil erosion using RUSLE (Revised universal soil loss equation) software. Because total live + dead ground cover remained high throughout the study, even at 10 to 11 months after treatment, glyphosate at commercial rates is unlikely to impact the effectiveness of tall fescue grassed waterways. However, at one month after treatment, glyphosate reduced live tall fescue cover as negative exponential functions of increasing glyphosate rate (e.g., equations of the form $Y = a * \exp(-X/b)$ or $Y = a + b * \exp(-X/c)$) for both mowed and unmowed treatments. Live and dead tall fescue cover were inversely related to one another. Broadleaf weed cover increased to fill gaps in the tall fescue stand by two months after treatment at glyphosate rates greater than 0.84 kg/ha. But, by 10 or 11 months after treatment, total (live + dead) tall fescue ground cover remained great enough (> 95%) to prevent erosion and was not impacted by either mowing or glyphosate rate. Enough live tall fescue cover remained to fill in gaps in the waterway.

TWO YEAR RESULTS USING AZAFENIDIN, SULFOMETURON, PENDIMETHALIN AND SIMAZINE ALONE AND IN COMBINATION ON TEN HARDWOOD TREE SEEDLINGS. John R. Seifert, Extension Forester, Department of Forestry and Natural Resources, Purdue University, Butlerville, IN 47223 and Dr. Keith Woeste, USDA Forest Service, Hardwood Tree Improvement and Regeneration Center, Purdue University, West Lafayette, IN 47907.

The study was established to evaluate the percent weed control and growth response of sulfometuron and azafenidin on nine hardwood species and one conifer species that were field planted as one year old seedlings.

Tree seedlings were planted on 5-15-00 with a machine planter. Herbicide applications were applied on 5-29-00 and 4-23-01 as a pre-bud break and 6-20-00 and 5-21-01 as a post-bud break treatment. Herbicide treatments were applied in 25 gallons of water with a plot sprayer.

Eighteen herbicide/combinations were applied to 10 tree species in a randomized complete block design with three replications and ten seedlings per species per plot. Test species were black cherry, black walnut, yellow poplar, red oak, white oak, flowering dogwood, northern bayberry, flowering crab, white ash and white pine.

Treatments were control, tilled, sulfometuron formulations at 0.75, 1.0, oz/ac; azafenidin at 2.5, 5.0, 7.5, 10, 20 oz/ac; simazine 4 qt/ac and pendimethalin 4 qt/ac. Also azafenidin was applied at 2.5 and 5.0 oz/ac with a tank mix each of sulfometuron at 0.50 and 0.75 oz/ac respectively. And finally azafenidin at 5.0 oz and sulfumeturon at 1.0 oz were applied over the top of fully leafed trees. All application rates are expressed as product and not active ingredient. Treatment responses were evaluated 90 days after application as percent bare ground.

The following treatments exhibited at least 60 percent weed control after 90 days: azafendin 5.0, 7.5, 10, and 20 oz of product per acre. Sulfometuron at 1.0 oz product per acre gave similar results. The treatments of simazine and pendumetholin gave 20 and 27 percent weed control after 90 days. Post application of azafenidin at 5.0 oz or sulfumeturon at 1.0 oz did not control existing annual weeds. Yellowing, slowing of weed growth and seed head suppression was noted, but the injured weeds recovered within 3 weeks.

Seedling survival was not impacted the first or second year by any of the treatments. Survival ranged from 87 to 100 percent throughout all species.

Tree seedling growth was affected differently by treatments and treatment rates. An index of ground line diameter x total height was used in the ANOVA to determine growth response by treatment. A mean ranking was then determined. Listed below are the treatments in descending order of growth response for all species: azafenidin 5.0oz, tilled, azafenidin 10, 7.5, 20 oz, pendimethilin 4 qt, simazine 4 qt, azafenidin 2.5 oz, sulfumeturon 0.75 oz, azafenidin 5.0 oz post leaf out, control, sulfumeturon 1.0 oz post leaf out and sulfumeturon 1.0 oz.

Within a treatment, individual tree species response was dependent on herbicide and rate. An examination of best growth response by species is listed below: white ash and flowering crab apple – azafenidin 20 oz, northern bay berry – simazine 4 qt, black cherry – azafenidin 10 oz, white pine and red oak – pendimethalin 4qt, black walnut, white oak, and yellow poplar – azafenidin 7.5 oz, and flowering dogwood azafenidin 2.5 oz.

WEED COMPACTION PRE-HERBICIDE TREATMENTS IN MID-ROTATION HYBRID POPLAR PLANTATIONS. Adam H. Wiese, Daniel A. Netzer, and Don Riemenshneider, North Central Research Station, Forestry Sciences Laboratory, Rhinelander, Wi. 54501.

We developed a mechanical roller system for a four-wheeled ATV to flatten tall weeds prior to herbicide application in 2 year-old and older hybrid poplar plantations. Standard between-row application systems require nozzles to be set sufficiently high to obtain complete weed coverage. But, such settings can result in drift or direct spray onto tree foliage, which damages trees. Our system allows nozzles to be positioned low to the ground while still maintaining complete coverage. We tested our system in a 3-year-old hybrid poplar plantation infested with 1-meter tall quack grass and Canada thistle in Northern Minnesota. Herbicide treatments consisted of glyphosate at two rates; glyphosate tank-mixed in various combinations with azafeniden, pendimethaline and imazaquin; plus an unsprayed control. Herbicides were applied with and without roller treatment in factorial combination. Each treatment combination was replicated twice. Percent weed control was estimated visually in all plots. The roller system significantly increased control of both grass and broadleaved weed species across all herbicide treatments compared to treatment without use of the roller. This conclusion was based on significant analyses of variance main effects attributable to roller treatment ($p < 0.0001$, grasses and broadleaves) and the lack of significant roller x herbicide treatment interactions ($p=0.092$ and $p=0.117$, grasses and broadleaves, respectively). Roller treatment increased percent grass control by 9.7%, percent broadleaf control by 17.8%, and percent control overall by 10.8%. Results also demonstrated significant main effects due to herbicide treatment. But, almost all the variance attributable to herbicide treatments was due to differences between the control plots and the herbicide treated plots, collectively. Thus, while the most effective herbicide treatment for controlling both grass (95.8% control) and broadleaves (93.2% control) appeared to be 1.5 qts. of glyphosate per acre, differences among herbicide combinations could not be declared significant. Mixing glyphosate with other herbicides (1.5 qt/ac glyphosate + imazaquin 2.8 oz.), (glyphosate .75 qt/ac + azafenidin 10oz.), (glyphosate 1.5 qt/ac + azafenidin 10 oz.), (glyphosate .75 qt/ac + imazaquin 2.8 oz.), (glyphosate .75 qt/ac + imazaquin, pendimethalin 3 pt.), (glyphosate 1.5 qt/ac + imazaquin, pendimethalin 3 pt.), and (glyphosate .75 qt/ac) somewhat decreased grass and broadleaf control compared to glyphosate alone. However, the lack of significant differences among treated plots (with or without roller treatment) made inferences regarding interacting chemistries unwarranted. Our pre-herbicide roller system is in an early developmental stage, yet it has already demonstrated significant promise when used in concert with a variety of herbicide combinations. To assess the effectiveness of the roller system further testing is required.

THE INFLUENCE OF SOIL CHARACTERISTICS ON WEED CONTROL AND DRY BEAN TOLERANCE. Brian M. Jenks and George O. Kegode, Weed Scientist and Assistant Professor, North Dakota State University, Minot, ND 58701 and Fargo, ND 58105.

Field studies were conducted in 2000 and 2001 at Minot, Underwood, and Fargo, ND to evaluate weed control and dry bean tolerance to sulfentrazone, flumioxazin, metribuzin, and flumetsulam. In 2000, at Minot, flumioxazin at 1.5 oz and sulfentrazone at 0.125, 0.25, or 0.5 lb/A, provided good to excellent control of biennial wormwood and kochia. Flumioxazin caused severe crop injury that resulted in a 44% yield reduction. There was little to no injury with sulfentrazone. Metribuzin, at 0.25 lb/A, caused little crop injury and provided excellent control of biennial wormwood and kochia. Flumetsulam&metolachlor (30.7 oz) or flumetsulam (0.8 oz) alone caused no crop injury, but provided little or no control of biennial wormwood and kochia. Lack of kochia control resulted in significantly lower yields. Soil pH and organic matter at this location was approximately 5.5 and 3.3%, respectively. In 2000, at Underwood, sulfentrazone caused 20% crop injury and reduced yields 200-300 lb/A. Flumioxazin caused some initial injury, but the crop recovered over time and yields were similar to other treatments. Soil pH and organic matter at Underwood was approximately 7.5 and 3.0%, respectively.

In 2001, at Minot, crop injury from sulfentrazone depended on location within the study area. Soil pH was much higher in block 1 than blocks 2 and 3. Soil pH was as high as 7.9 in block 1, while soil pH in blocks 2 and 3 ranged from 5.0 to 6.7. Organic matter was 2.1 to 2.8% in block 1, while organic matter was 2.7 to 3.8 in blocks 2 and 3. Sulfentrazone caused moderate to severe injury in plots with higher soil pH and lower organic matter. Dry bean yields were reduced 30 to 60% in the higher pH, sulfentrazone-treated plots compared to the lower pH plots.

Flumioxazin caused 16% visible injury and 18% yield reduction. Flumioxazin provided good to excellent control of biennial wormwood and kochia. Metribuzin caused 7% crop injury and provided good control of biennial wormwood and kochia. Flumetsulam&metolachlor or flumetsulam alone caused little dry bean injury, provided fair to good control of biennial wormwood, but provided no kochia control. Biennial wormwood control with flumetsulam was greater in plots with higher soil pH. Lack of kochia control resulted in significantly lower yields.

In 2001, in Fargo, sulfentrazone, flumioxazin, metribuzin, and flumetsulam provided excellent control of biennial wormwood in soybean. Soil pH and organic matter at Fargo was approximately 7.5 and 4.5%, respectively.

ROW SPACING INFLUENCES CRITICAL TIME FOR WEED REMOVAL IN SOYBEAN. Stevan Z. Knezevic, Sean Evans, and Mike Mainz, Assistant Professor, Graduate Research Assistant, and Research Technologist, Haskell Ag. Lab., University of Nebraska, Concord, NE, USA, 68728-2828.

Soybean crop in United States is grown under row spacing ranging from 7.5" to 38". Commonly used row spacings are 7.5" and 30", some soybean acres are grown in 15" and very few in 38" wide rows. Row spacing influences the time of canopy closure, thus regulating the amount of light that reaches soil surface. Light is an important source for growth and development for which soybean competes for against weeds. This raises the question whether reducing soybean rows spacing affects weed competitiveness and consequently influence the critical time for weed removal (CTWR). CTWR is a period in the crop growth cycle when weed control must be initialized to prevent yield losses. Determining effects of row spacing on the CTWR will aid in optimizing weed control strategies. Recognizing this potential interaction will improve acceptance of integrated weed management practices. Field studies were conducted in 1999, 2000 and 2001 at Mead and 2000 and 2001 Concord in eastern Nebraska to determine the effects of three row spacings on the CTWR in dry land soybean. The three soybean row spacings were 7.5", 15" and 30". Experimental design was a split-plot with row spacing as the main plot and weed duration as sub-plots. A set of six subplots had increasing durations of weed presence up to predetermined soybean growth stages. The logistic equation was fit to data representing increasing duration of weed presence. Earliest CTWR occurred in the widest rows (30"), and coincided with the soybean first trifoliate stage. Latest CTWR occurred in the narrowest rows (7.5"), and coincided with the third trifoliate. CTWR in 15" rows occurred at the 2nd trifoliate. Practical implications are that planting soybean in wide rows (30") reduces early season crop's tolerance to weeds requiring earlier weed management programs than in narrower rows.

WEED CONTROL AND VARIETAL PERFORMANCE IN CYSTX™ AND PI88788 SOYBEAN CYST NEMATODE RESISTANT SOYBEANS. John W. Leif and James Gaffney, Field Biologist and Regional Research Manager, BASF Corporation, St. Johns, MI, 48879 and Champaign, IL, 61875.

Soybean cyst nematode (SCN) has spread to 26 states since an initial discovery in North Carolina in 1954. Soybean producer losses due to SCN have been estimated at $400 million in Illinois alone and up to $1.7 billion nationwide. Current SCN management practices include soil sampling for early detection, rotations to non-host crops, and use of SCN-resistant soybean varieties. Most current SCN resistant varieties obtain resistance from either ‘Peking’ or ‘PI 88788’ breeding lines. CystX™ was developed at Purdue University.

Due to the novelty of CystX™ technology, field studies were conducted in Illinois and Kentucky to evaluate SCN-resistant and susceptible varieties for agronomic traits, yield, SCN management, and weed control options in the presence or absence of SCN. Conventional and glyphosate resistant soybean varieties which were SCN susceptible or contained either the PI 88788 or CystX™ form of SCN resistance were included in the study. All four sites were in a corn/soybean rotation, and were sown to field corn the previous season. Soil samples were taken and initial egg counts were determined in spring 2001 at three sites in Illinois and one site in Kentucky. Subsequent soil samples were taken and egg counts determined for the selected varieties in September or October. Soybean roots were evaluated throughout the season for the presence or absence of cysts. This study was maintained weed-free with soil-applied imazaquin and pendimethalin combinations. A second study evaluated weed control and CystX™ variety response to pendimethalin soil-applied followed by a combination of imazamox plus acifluorfen postemergence.

Based on the reproductive factor (final egg count divided by initial egg count), both the PI 88788 and CystX™ varieties were effective for SCN management. Final egg counts for these varieties were approximately equal to or less than the initial egg counts where SCN was present. In SCN susceptible varieties, final egg counts increased from 4 to 18 times initial numbers. Cysts were observed attached to roots of both the susceptible and PI 88788 varieties, but were not observed on roots of CystX™ varieties. Agronomic qualities of the varieties were similar: emergence and stand count were acceptable, lodging did not occur at any location, and disease was not apparent. Yields of CystX™ varieties were equal to or greater than the other varieties at 3 of 4 sites, regardless of SCN pressure. Near 100% control of giant foxtail, common waterhemp, and lambsquarter was achieved with the combination of pendimethalin followed by imazamox/acifluorfen, with only transient crop response. Based on these studies, CystX™ soybean varieties offer an effective management tool for soybean cyst nematodes, and excellent weed control options exist for both conventional and glyphosate resistant varieties.

CystX™ is a registered trademark of Access Plant Technology.

SOYBEAN WEED CONTROL FROM A NEW FORMULATION OF S-METOLACHLOR PLUS METRIBUZIN. Adrian J. Moses and Joseph A. Bruce, Syngenta Crop Protection, Greensboro, NC.

The current Boundary 7.8 EC formulation (s-metolachlor:metribuzin) is highly viscous in cold temperatures and presents handling problems especially in bulk handling systems located in northern areas. A new s-metolachlor:metribuzin 6.5 EC formulation is being developed to improve cold temperature handling properties. Trials were conducted to compare soybean tolerance and weed control of the two formulations. Also, tank-mix compatibility and efficacy with various herbicides were evaluated. No mixing or handling problems were observed in these trials. Both herbicide formulations provided comparable soybean tolerance and weed control.

DISCOVERY OF RESOLVED ISOMER OF CLETHODIM AND ENHANCED GRAMINICIDE ACTIVITY. Gerald L. Wiley, Ronald E. Jones and Kevin M. Perry, Field Market Development Specialist, Research Specialist and Product Development Manager,Valent USA Corporation, Walnut Creek, CA 94596.

Clethodim is a cyclohexanedione-classified herbicide marketed in the United States by Valent USA Corporation under the trade name Select® 2EC Herbicide. Select has become the most widely used post emergence graminicide product for annual and perennial grass control in the United States and is now registered for use on more than 70 crops. Application rates range from 0.063 to 0.25 lb/A depending on the crop and target weeds.

The current *Select* 2 EC formulation is a racemic mixture. Valent has discovered and confirmed through 3 years of research that one of the optical isomers has enhanced biological activity when compared to the other isomeric form. Research trials have been conducted in both greenhouse and field trials involving the following weeds: barnyardgrass, large crabgrass, giant foxtail, shattercane, volunteer corn, volunteer wheat, annual bluegrass, rhizome johnsongrass, common bermudagrass, woolly cupgrass and quackgrass. Depending on weed species, biological activity is 25-50% greater with the enhanced isomer. In addition to field efficacy research, in-vitro bioassays for the inhibition of Acetyl -Coenzyme A Carboxylase (ACCase) isolated from corn and barnyardgrass have been completed. Inhibition of ACCase in this research confirms the findings in the field studies that one isomeric form is far superior to the other.

Implications of such a discovery include future commercialization of an enhanced isomer formulation, lowering per acre uses rates on an active ingredient basis and lessening the overall amount of clethodim being used in the environment. This discovery has already been awarded a patent by the U.S. patent office.

V-10086 HERBICIDE: A NEW POSTEMERGENCE PRODUCT FOR SOYBEANS; PRODUCT INTORDUCTION AND TECHNICAL OVERVIEW. Mark J. Kitt, Alan R. Kurtz, Jeffery D. Smith, Gerald R. Wiley, Ronnie E. Jones and Kevin M. Perry, Field Marketing Development Specialists, Research Specialist, and Product Development Manager, Valent U.S.A. Corporation, Walnut Creek, CA 94596.

V-10086 is a new novel postemergence soybean herbicide with a built-in adjuvant system developed by Valent U.S.A. Corporation. V-10086 contains 23.2% lactofen and 76.8% inert ingredients formulated as a 2.0 lb/gal emulsifiable concentrate. Lactofen unlike other diphenyl ether herbicides such as fomesafen and acifluorfen, is essentially insoluble in water and thus in the past this characteristic has dictated what type of lactofen formulation could be commercially produced. The formulation of V-10086 is unique in that the built-in adjuvant system has properties that not only dissolve and emulsify the lactofen technical to create a stable formulation, but also the properties to enhance weed control. It is due to this unique built-in adjuvant system that crop oil concentrate can be omitted to obtain broadleaf weed control as well as broadleaf and grass weed control when tank mixed with clethodim herbicide. V-10086 when applied to soybeans has shown up to 50% less crop response compared to the current lactofen formulation plus crop oil concentrate. V-10086 is non-ALS chemistry and therefore is effective in managing resistant biotypes including waterhemp. V-10086 is not persistent in the soil so crop rotation restrictions are not a concern. V-10086 will be launched in 2002 into key midwestern states where waterhemp is a key weed, and sold under the trade name of Phoenix™.

V-10086: A NOVEL NEW POSTEMERGENCE HERBICIDE FOR BROADLEAF AND GRASS WEED CONTROL IN SOYBEAN. Jeffrey D. Smith, Alan R. Kurtz, Mark J. Kitt, and Kevin M. Perry, Field Marketing Development Specialists and Product Development Manager, Valent U.S.A. Corporation, Walnut Creek, CA 94596.

V-10086 is a new postemergence soybean herbicide developed by Valent U.S.A. Corporation that contains 23.2% lactofen and 76.8% inert ingredients formulated as a 2.0 lb/gal emulsifiable concentrate. The novelty of this herbicide is that a portion of the inert ingredients is composed of an adjuvant system built directly into the formulation. This adjuvant system acts as a solvent for lactofen technical and allows for effective weed control with minimal crop response. It also minimizes the need for additional adjuvants since only a nonionic surfactant at 0.125 to 0.25 % v/v is required.

Research indicates that V-10086 applied at 0.125 to 0.195 lb/A provides effective control of key broadleaf weeds species such as waterhemp, pigweed, ragweed and nightshade. V-10086 tank-mixed with clethodim (i.e. Select® 2 EC Herbicide) provides excellent grass control without the addition of a crop oil concentrate, normally required for all clethodim applications. Crop oil concentrates are not recommended when V-10086 is applied alone or in combination with other herbicides unless weeds are stressed or approaching their maximum labeled heights for control. V-10086 will be sold under the trade name of Phoenix™ Herbicide in 2002.

WATERHEMP MANAGEMENT STRATEGIES IN SOYBEANS WITH FLUMIOXAZIN. Alan R. Kurtz, Mark J. Kitt and John A. Pawlak, Field Market Development Specialists and Product Development Manager, Valent U.S.A. Corporation, Walnut Creek, CA 94596.

Flumioxazin (Valor™ Herbicide) is an N-phenylphthalimide derivative herbicide marketed for use in soybeans and peanuts in the United States by Valent USA Corporation. Flumioxazin is a protoporphyrinogen oxidase (PPO) inhibitor herbicide with non-selective contact activity in burndown applications, as well as residual control of a number of troublesome broadleaf weeds, including waterhemp spp. In soybeans, flumioxazin may be used at rates from 0.063 to 0.094 lb/A in fall or spring applications prior to planting, or in preemergence applications up to 3 days after planting.

Research and field experience have indicated that preplant or preemergence applications of flumioxazin can provide residual control of multiple flushes of waterhemp, reducing or eliminating the need for early-season applications of postemergence herbicides. In areas with heavy waterhemp pressure, season-long weed control can be obtained with programs utilizing a preplant or preemergence application of flumioxazin, followed by a single postemergence herbicide application to control grasses and additional broadleaf weeds. In addition to waterhemp, flumioxazin controls or suppresses numerous weeds which may be difficult to control with postemergence herbicides, including common lambsquarters, morningglory spp., and annual nightshade spp. Fall applications of flumioxazin can control important winter annual and perennial weeds, including chickweed, dandelion and horseweed (marestail), with the flexibility to plant soybeans or other crops including field corn, sorghum, sunflowers or wheat, the following spring.

VERSATILITY OF IMAZETHAPYR PLUS GLYPHOSATE (PRE MIX) AT DIFFERENT APPLICATION TIMINGS AND WEED STAGES AS COMPARED TO GLYPHOSATE ON GLYPHOSATE TOLERANT SOYBEANS. Mauricio Britva, Kenneth L. Carlson, Thomas A. Hayden, Dave Johnson, Troy Klingaman, E. James Retzinger, and Kristine J. Schaefer, Biology Project Leader - Herbicides BASF Corporation, Research Triangle Park, NC; and Field Biologists BASF Corporation, Lincoln, NE, Owensboro, KY, St. Paul, MN, Seymour, IL, West Des Moines, IA, and Adel, IA.

Field studies were conducted at seven locations across the Midwest to evaluate imazethapyr plus glyphosate (Extreme®[1]) and glyphosate (Roundup Ultra®[2]) on glyphosate tolerant soybeans at different weed stages to compare the application windows for these herbicides. These studies included application timings other than those recommended in the approved label directions[3]. Herbicides were sprayed postemergence at four different weed stages, 6", 12", 18" and 24" in height. Imazethapyr plus glyphosate was applied at 0.813 lb ai/A (0.063 lb ai/A imazethapyr + 0.75 lb ai/A glyphosate) with 0.125% v/v nonionic surfactant plus ammonium sulfate at 17 lbs/100 gallons of spray solution. Glyphosate was applied at 1 lb ai/A plus ammonium sulfate at 17 lbs/100 gallons of spray solution. Results from three or more different locations indicate that imazethapyr plus glyphosate provides control equal to glyphosate for common waterhemp, velvetleaf, giant ragweed, and giant foxtail at all four application timings. Indications for weed species with two or less locations are that imazethapyr plus glyphosate provided weed control equal to glyphosate on smooth pigweed, common lambsquarter, common sunflower, eastern black nightshade, common cocklebur, woolly cupgrass, and green foxtail. Results from a limited number of locations also indicated that imazethapyr plus glyphosate demonstrated superior control of ivyleaf morningglory, yellow nutsedge, fall panicum, and seedling johnsongrass as compared to glyphosate at the earliest application timing of 6”. Residual control from imazethapyr plus glyphosate is responsible for the weed control differences observed when compared to glyphosate. Soybean yield results indicate that imazethapyr plus glyphosate treatments yielded equal to glyphosate when compared at similar application timings. Soybean yields were greater for the earlier application timings. Weed control results from trials conducted at seven different locations across the Midwest indicate that imazethapyr plus glyphosate’s (Extreme®) application window is similar to that of glyphosate (Roundup Ultra®).

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[1] Extreme is a trademark of BASF Corporation
[2] Roundup Ultra is a trademark of Monsanto Company
[3] The results presented are provided for informational purposes and are not intended to promote the use of the products other than as instructed in the approved labeling.

WORKER PROTECTION SAFETY RULES ADJUSTED TO REFLECT RESEARCHERS TRAINING AND JOB TASKS. Robert R. Hedberg, WSSA, Washington DC, E. James Retzinger Jr., BASF, West Des Moines, IA, Henry P. Wilson, VA Tech, Painter, and James V. Parochetti, CSREES/USDA, Washington, DC.

In 1996 the Environmental Protection Agency (EPA) published the Worker Protection Standard (WPS) guidelines designed to "-reduce the risks of illness or injury resulting from workers and handlers occupational exposures to pesticides used in the production of agricultural plants on farms or in nurseries, greenhouses, and forests and also from the accidental exposure of workers and other persons to such pesticides." An unofficial group formed in 1996 during the term of WSSA President Steve Duke to petition the EPA for an exemption to some of the provisions of WPS. Cal Messersmith in 1997 officially commissioned this group as Special Committee S53: Worker Protection Standards Task Force. With the appointment of Robert Hedberg, the WSSA Director of Science Policy this group had an ever-present voice in Washington D.C. Dan Hess made several contacts with the Presidents of the Entomology Society of America, the American Phytopath Society and the National Association of Independent Crop Consultants and thus formed the Consortium of Concerned Scientists.

The WPS Task force petitioned EPA for four changes to the 1997 WPS Guidelines these were:

1. Exempt researchers who hold a Category 10 Research and Demonstration endorsement on their Pesticide applicator's license.
2. Eliminate the Posting of each registered compound for each experiment in research trials.
3. Allow the field notebook be the Central Posting site research areas.
4. Allow researchers early re-entry in to plot areas adjacent to treated areas for data collection and the initiation of trials in both field and greenhouse settings. This is the same exemption granted to the Certified Crop Advisors.

The language in the WPS is directed at farm workers whose primary job was the harvesting of fruits and vegetables. Exemptions to WPS guidelines allowed irrigation workers early re-entry privileges so crops could be irrigated in a timely manner. However, there were no provisions made to address job tasks associated with researchers who apply and evaluate registered and experimental pesticides. Furthermore, only labeled pesticides were covered under the auspices of WPS.

After three meetings with EPA and contacts by Rob Hedberg a letter of clarification was received in July of 2001 which addressed the four points of concern to WSSA members.

1. There was no mention of exemption from WPS for persons who hold a Category 10 Research and Demonstration endorsement.
2. EPA acknowledged that WPS posting would not apply to labeled pesticides used as standards in research trials. Since experimental pesticides are not covered under WPS, no posting of research trials would be needed. However, if maintenance chemicals of labeled products were applied they would need to be posted.
3. The field notebook used by the researcher would be recognized as the central posting site if accessible to workers at that research site.
4. Researchers would now have the same early re-entry exemption as granted certified crop advisors.

EXPERIENCING A CHEMICAL STORAGE FIRE AT A RESEARCH FACILITY. David Nicolai, Gregory K. Dahl, Eric Spandl, Joe V. Gednalske, and Kent Kutnick, Agronomist, Research Coordinator, Agronomist, Product Development and Registration Manager, and Regulatory Manager, Agriliance, St. Paul, MN 55164.

A chemical storage building, containing pesticides used for research and demonstrational programs, was destroyed by a fire on August 13, 2001. The storage building was designed for hazardous materials and was owned by Agriliance and located at the University of Wisconsin River Falls.

Upon discovery of the fire, actions were taken to ensure no person was in the building, to verify the contents, and to contain and extinguish the fire. Foam was used instead of water which minimized out-of-building movement of contaminants. The structure of the storage building remained intact and the fire and most contamination was contained to the building. A hazardous waste consultant and cleaning contractor were contacted and on site the same day. Contamination outside the building was limited to a small area on the pavement and contained with floor drying compound and placed in approved storage barrels by the contractor the same day. Fire crews that entered the building decontaminated their turn-out gear with water that also was contained and stored.

Self-contained breathing apparatus and protective clothing was worn by the fire crew and contractors entering the building or doing initial external cleanup. Product remains of approximately 130 pesticides were identified, segregated and placed in barrels by the contractor. Surfaces of the interior were decontaminated and removed and insulation removed and stored as contaminated waste. The building was removed and salvaged for scrap metal. Fire damaged pesticides, containers, and contaminated debris were disposed of in the Northwest Clean Sweep program. This is a cooperative program supported by the Wisconsin Department of Natural Resources, the Wisconsin Department of Agriculture, Trade and Consumer Protection, the northwest Regional Planning Commission, the U.S. Environmental Protection Agency, and 10 Wisconsin counties.

Key issues were having employees understand the Emergency Response Plan (what to do, who to call, and the proper order), proper response of the Fire Department, regular contact with regulatory agencies, access to all MSDS's, and dealing with the media. Improving inventory management, maintaining additional copies of MSDS's at a separate site, making sure employees understand the Emergency Response Plan, and meeting regularly with people such as the Fire Department to familiarize them with the facility and its contents are planned for the future. In developing a new facility, some considerations are contamination and containment potential, location of the building, and integration or separation of mixing and storage.

HERBICIDE OPTIONS FOR CANADA THISTLE CONTROL IN PASTURES. Ryan P. Tichich and Jerry D. Doll, Graduate Research Assistant and Professor, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

Canada thistle remains one of Wisconsin's most serious weeds in pastures and it seems particularly adapted to management intensive grazing systems. We have done three field trials in 2000 and 2001 to evaluate the performance and economics of Canada thistle control in pastures at agricultural research stations near Lancaster and Arlington, WI. Two of the three studies were short-term (one-year treatments) and the other is a long-term study. The long-term trial is designed to treat as often as needed with either the same herbicide used in 2000 or by switching to two alternative treatments. In this trial our primary interest is in the economics of each system of control and it will be conducted for four or more years.

Herbicides were applied when Canada thistle plants were in the bud to early flower growth stage in 190 L water/ha in all trials. Appropriate additives, if any, were used as recommended. Thistle stem densities were determined in all plots in the long-term trial before herbicides were applied in June of each year. The one-treatment trial was grazed until 2 days before applying herbicides in 2000 and the site was mowed 30 days before treating in 2001.

Visual ratings in the one-year trials found that thistle control in 2000 was less than anticipated, probably as a result of the grazing that preceded application. Clopyralid and the premix of dicamba plus diflufenzopyr gave the best control as single products. Adding diflufenzopyr to clopyralid, dicamba, metsulfuron or quinclorac increased herbicide efficacy by 36% (60% control without diflufenzopyr versus 96% with it).

The long-term study site was also intensively grazed for several days before we treated thistles in 2000, and this seems to have reduced control. Ratings indicated poor to acceptable kill of treated vegetation, but plant population counts in 2001 found little long-term impact except for the treatments that included clopyralid. Based on thistle densities, all plots needed retreatment in 2001. Clopyralid (213 g ae/ha) averaged 92% visual control and reduced the thistle population 17% compared to the original density. Metsulfuron (13 g ai/ha) averaged 82% control but thistle populations increased 28%. Dicamba (1140 g ae/ha) averaged 51% control with no effect on thistle density. Tank mixing half rates of clopyralid and dicamba gave 81% control and slightly reduced the population.

While the most economical treatment for two years of application is metsulfuron at $40/ha, this treatment had the least impact on the thistle population. The most costly treatment was two applications of clopyralid at $202/ha. Making an initial application of clopyralid and then changing to more economical treatments as needed seems to be a promising Canada thistle management strategy. If the synergistic response from diflufenzopyr is consistent and this becomes a labeled treatment, additional cost effective systems will be possible.

CHEMICAL CONTROL OF CANADA THISTLE ON RANGELAND AND PASTURES. Vanelle F. Carrithers, Field Research Biologist, Dow AgroSciences, Mulino, OR 97042, Robert N. Klein, Professor, North Central Research and Extension Center, University of Nebraska, North Platte, NE 69101, Stevan Z. Knezevic, Assistant Professor, University of Nebraska, Concord, NE 68728, Robert A. Masters*, Field Research Biologist, Dow AgroSciences, Lincoln, NE 68506, Todd C. Geselius, Field Research Biologist, Dow AgroSciences, Fargo, ND 58104, Jonathan D. Green, Professor, University of Kentucky, Lexington, KY 40546, and Patrick L. Burch, Field Research Biologist, Dow AgroSciences, Christiansburg, VI 24073.

Canada thistle is a widespread perennial invasive and noxious weed in the United States and Canada. This invasive plant is found throughout the northern U.S., from northern California to Maine and south to Virginia. In much of this region the species commonly infests cropland, rangeland, pastures, roadsides, and rights-of-way. On rangeland and pastures, infestations often reach densities that reduce livestock carrying capacity. This reduction results, in part, from direct interference of this plant with desirable forages. In addition, livestock avoid infested areas because the spines, which protrude from leaf margins, deter grazing. The invasiveness of this plant arises from its capacity to produce abundant plumed seeds that are readily dispersed by wind and to reproduce vegetatively from buds arising from an extensive root system. Research was conducted at several locations to determine the response of Canada thistle to picloram, clopyralid + triclopyr, fluroxypyr + triclopyr, fluroxypyr + picloram, 2,4-D, metsulfuron, and dicamba. Canada thistle control usually exceeded 80% 60 days after spring 2001 applications of spray solutions containing 420 g ae/ha picloram, 368 g ae/ha clopyralid + 1103 g ae/ha triclopyr, or 231 g ae/ha picloram + 231 g ae/ha fluroxypyr. In contrast, Canada thistle control was usually less than 60% 60 days after application of 2,4-D at 2128 g ae/ha, metsulfuron at 12.6 g ai/ha, or dicamba at 1680 g ae/ha. Picloram- and clopyralid-containing treatments provided season-long Canada thistle control superior to that of other treatments.

CONTROL OF THE NOXIOUS WEED SERICEA LESPEDEZA IN RANGELAND IN SOUTHEAST KANSAS. Gary L. Kilgore and Jeffrey L. Davidson, Professor and County Extension Agricultural Agent, Kansas State University, Chanute, KS (165).

Sericea Lespedeza control is defined as not letting the plant produce seed and reducing the weed population as much as possible. Research and educational programs centered on several methods: chemical, mowing and grazing. Currently, two herbicides are recommended metsulfuron applied in bud through full bloom stage or triclopyr applied to vegetative growth in June. Depending on topsoil thickness and rainfall patterns, mowing in late July will greatly reduce or eliminate seed production. When properly stocked, cattle grazing through mid-July can reduce flowering too. Goats eat Sericea Lespedeza too. When stocked heavy enough they will reduce seed production by 96%. Currently no method eliminates all plants.

HERBICIDE SCREENING FOR SERICEA LESPEDEZA CONTROL. Walter H. Fick and Rodney A. Kunard, Associate Professor and Assistant Scientist, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Sericea lespedeza is an invasive legume on range and pasture land in the central and southern Great Plains. The species was designated as a state-wide noxious weed in Kansas in 2000. Previous research on sericea lespedeza control has identified metsulfuron and triclopyr as the most effective herbicides. These studies concentrated on treating sericea lespedeza during the late vegetative and full bloom stages. The objective of the current study was to screen a number of herbicides labeled for range and pasture for sericea lespedeza control when applied during a vegetative growth stage. Twenty-five herbicide treatments were applied using a CO_2-powered backpack sprayer in 187 L ha^{-1} spray volumes on June 21, 2000 at a site near Blaine, KS. Herbicides tested included dicamba (0.28 and 0.56 kg ha^{-1}), dicamba + 2,4-D (0.25 + 0.8 and 0.5 + 1.6 kg ha^{-1}), picloram (0.14 and 0.28 kg ha^{-1}), picloram + 2,4-D (0.14 + 0.5 and 0.27 + 1 kg ha^{-1}), triclopyr (0.28 and 0.56 kg ha^{-1}), metsulfuron (0.0084 and 0.0168 kg ha^{-1}), triasulfuron (0.0147 and 0.0294 kg ha^{-1}), triasulfuron + dicamba (0.025 + 0.14 and 0.031 and 0.18 kg ha^{-1}), 2,4-D (1.1 and 2.2 kg ha^{-1}), fluroxypyr (0.14 and 0.28 kg ha^{-1}), triclopyr + clopyralid (0.32 + 0.11 and 0.63 + 0.21 kg ha^{-1}), and triclopyr + 2,4-D (0.28 + 0.56 and 0.56 + 1.12 kg ha^{-1}). Environmental conditions during herbicide application were 23^{o}C air temperature, 54% relative humidity, and 2.2 to 3.6 m sec^{-1} wind speed. Sericea lespedeza was about 20 to 25 cm tall with an average density of 56 stems m^{-2} in the check plots. Density reduction was determined 1 month (MAT) and 1 year (YAT) after treatment using 4, 0.25-m^2 frames. Percent control for each herbicide treatment was adjusted for changes in the check plots. Data were analyzed as a randomized complete block design with four replications and means separated using LSD at $p \leq 0.05$. Triclopyr (0.56 kg ha^{-1}), triclopyr + 2,4-D (0.56 + 1.12 kg ha^{-1}), and fluroxypyr (0.28 kg ha^{-1}) were the only treatments that provided > 90% density reduction 1 MAT. These same treatments plus triclopyr + clopyralid (0.63 + 0.21 kg ha^{-1}) and triclopyr + 2,4-D (0.28 + 0.56 kg ha^{-1}) provided > 80% density reduction of sericea lespedeza 1 YAT. All other treatments provided < 50% control 1 YAT.

EFFICACY OF THREE HERBICIDES ON TWO STAGES OF SERICEA LESPEDEZA SEEDLINGS. Rodney A. Kunard, Walter H. Fick, and Kassim Al-Khatib, Assistant Scientist, Associate Professor, and Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Sericea lespedeza is an invasive perennial legume that has invaded rangelands of the central and southern Great Plains. Herbicides are commonly recommended for control at a vegetative to early reproductive stage of growth. Current treatments vary in effectiveness and must be repeated on a regular basis. To develop new best management practices, the seedling stage is being evaluated to identify if lower cost treatments are available to extend the effectiveness of the original treatment. The objective of this study was to evaluate the rate effect of picloram, triclopyr, and metsulfuron on two different stages of sericea lespedeza. Plants were grown in the greenhouse from seed. Herbicides were applied with a bench-sprayer system at 187 L ha^{-1} spray volume at 0, 0.25X, 0.5X, X, and 2X rates. The X rates were 0.14, 0.56, and 0.021 kg ha^{-1} of picloram, triclopyr and metsulfuron, respectively. A non-ionic surfactant at 0.25% v/v was added to all treatments. At herbicide application, plants were 8 to 18 cm and 20 to 46 cm tall at stage 1 and 2, respectively. Plants were visually evaluated for damage 1 to 4 weeks after treatment (WAT). Picloram and triclopyr exhibited rate effects at both stage 1 and 2. Damage on triclopyr treated plants for both stage 1 and 2 were similar for a given rate. At 4 WAT, picloram (0.14 kg ha^{-1}) showed more damage on sericea lespedeza plants treated at stage 1 (92%) than at stage 2 (64%). At the X rates, picloram and triclopyr caused greater damage than did metsulfuron. Picloram at 0.14 kg ha^{-1} may provide more economical control of seedlings than currently labeled herbicides recommended for sericea lespedeza control.

WEED CONTROL IN ESTABLISHED ALFALFA WITH DORMANT SEASON HERBICIDES. Stewart R. Duncan and Dallas E. Peterson, Associate Professor and Professor, Department of Agronomy, Kansas State University, Hutchinson, KS 67501 and Manhattan, KS 66502, and Kenneth L. Carlson, Research and Development, BASF, Lincoln, NE 68506.

This field study was initiated to determine the efficacy of labeled and experimental herbicides on winter annual weeds in established alfalfa, and to determine the effects on alfalfa forage yield and quality. Mouseear chickweed, henbit and shepherds-purse were controlled except when treated with the lowest recommended rates of diuron and imazethapyr, and the lowest proposed rate of imazamox. A medium labeled rate of diuron (1.6 lb/A), low and medium labeled rates of hexazinone (0.5 and 1 lb/A, respectively) and experimental rates of sulfentrazone (0.29 and 0.38 lb/A) all resulted in reduced alfalfa forage production. Visual injury to alfalfa was present 21 d after treatment in medium rate hexazinone and all sulfentrazone treated plots and remained visible in sulfentrazone treated plots until the first cutting. Forage quality, as reflected by the Relative Feed Value, was unaffected by the different herbicide treatments, but was reduced in the untreated checks.

IMPACT OF IMAZAPIC ON WESTERN PRAIRIE FRINGED ORCHID, A THREATENED SPECIES, IN RANGELAND AND PASTURES. Kenneth L. Carlson, Scott Wessel, Gerry Steinauer, and Jeremy Lubke, Field Biologist BASF Corporation Lincoln, NE 68506, Wildlife Biologist II Nebraska Game and Parks Commission Norfolk, NE 68701, Botanist Nebraska Game and Parks Commission Aurora, NE 68818, and Student Wayne State College Wayne, NE 68787.

Western prairie fringed orchid (*Platanthera praeclara*) is a native plant of the American tallgrass prairie and is a threatened plant species under the Endangered Species Act. It has been found west of the Mississippi River to the Sandhills of Nebraska, North to Manitoba, Canada and as far south as northeastern Oklahoma. Habitat sites for the western prairie fringed orchid is typified by areas of a high soil moisture profile in a tall grass prairie. Prior to pioneer settlement it was commonly found throughout this area. It is estimated that population location numbers have declined by more than 60%, and plant numbers to an even greater extent. Several factors account for the decline in population of the western prairie fringed orchid. Early habitat losses due to plowing of the prairie by settlers, followed by mechanized agriculture when tractors replaced draft animals resulted in decreased populations. More recent threats to the orchid population include haying of areas instead of grazing, reduced pollination due to reduced hawkmoth numbers, and effects from noxious weeds. The effects from noxious weeds such as leafy spurge include aggressive direct competition, as well as injury from herbicide applications designed to control the leafy spurge. Populations of leafy spurge are commonly found in the same habitat as the western prairie fringed orchid in northern Nebraska. Imazapic, a member of the imidazolinone herbicide family, is a broad spectrum herbicide that provides contact, translocation, and residual activity on leafy spurge. Imazapic (is currently sold under the tradename Plateau® herbicide), and is registered for the control of over 90 grass and broadleaf weed species, including key perennial weeds. The objective of this study was to evaluate the impact of fall applications of imazapic, at rates used for the control of leafy spurge, on the population of western prairie fringed orchids. Approval for this research was granted by EPA through Nebraska Game and Parks Commission. Two sites containing western prairie fringed orchid populations were located in Pierce County Nebraska. Plants were located, mapped, flagged, and tagged in June of 2000. Imazapic was applied to 44 areas containing a western prairie fringed orchid using a CO_2 backpack sprayer at 0.188 lb ai/A, the maximum leafy spurge use rate, in combination with a methylated seed oil and liquid nitrogen as spray adjuvants on September 20, 2000. An additional 44 plants were left untreated for comparison. All plant areas were re-located on June 28, 2001 and the presence or absence of the western prairie fringed orchid was recorded. Based on counts from both sites, the number of plants present in the imazapic treated plots was greater than or equal to the number present in the untreated plots. Imazapic effectively controls leafy spurge. Dry weather in 2000 and anthracnose leaf blight greatly affected orchid reemergence, growth, and flowering. These factors greatly influenced our ability to record observations in this first year. The fact that nearly equal numbers of orchids reemerged in both the imazapic treated and untreated plots suggests that imazapic does not impact western prairie fringed orchid populations. Imazapic is currently registered under Section 18 emergency use labeling for the control of leafy spurge in rangeland and pastures in Nebraska, Colorado, Idaho, Montana, North and South Dakota, and Wyoming. Section 3 registration of imazapic for use in rangeland and pastures is anticipated by the end of 2001. Plans are to continue this research by looking at the impact that consecutive year applications of imazapic have on western prairie fringed orchid populations. In most heavy populations of leafy spurge consecutive year applications will be required to retain effective control.

Thanks to Nebraska Game and Parks Commission, especially Scott Wessel and Gerry Steinauer, and to Jeremy Lubke a Wayne State College student for their assistance in conducting this research.

Thanks also to the Venteicher and Zimmerman families for allowing this research to be conducted on their land.

WEED MANAGEMENT WITH IMAZAPIC IN WARM-SEASON GRASS AND LEGUME MIXTURES. Daniel D. Beran, Market Development Specialist, BASF Corporation, Des Moines, IA 50311; Gary L. Kilgore, Crops and Soils Extension Specialist, Kansas State Research and Extension, Chanute, KS 66720; and Robert A. Masters, Dow AgroSciences, Lincoln, NE 68506.

Separate studies were conducted to evaluate the utility of imazapic for establishing a native grass and forb mixture, and to determine the efficacy of imazapic for controlling johnsongrass and musk thistle in native grass stands and legume stands. Experiments were initiated at Mead and North Platte, NE in 1997 to determine the effect of imazethapyr and imazapic on the establishment of a prairie mixture comprised of native grasses, legumes, and asters. Based on grass canopy cover and legume density, imazethapyr or imazapic applied at preemergence 35 g/ha resulted in successful establishment of the native grasses and legume components. Experiments were conducted in southeastern Kansas in 2000 and 2001 to determine the efficacy of imazapic for selectively controlling johnsongrass in infested stands of native warm-season grasses. Herbicide treatments were applied on June 6, 2000 near Yates Center, KS to perennial johnsongrass that was 30-60 cm tall. Measured 14 weeks after treatment, imazapic applied at 140 and 175 g ai/ha resulted in 88 and 99% control of rhizome johnsongrass, respectively. Similarly, imazapic at 175 g/ha plus 2,4-D at 350 g/ha resulted in 91% control of johnsongrass. A final study was initiated in spring 2001 near Beatrice, NE to determine the efficacy of imazapic for controlling musk thistle in an established stand of warm-season grasses, alfalfa and red clover. Imazapic applied at 140 g/ha on May 15, 2001 reduced musk thistle flowering by 95% when measured 6 weeks after treatment. Imazapic at this rate also had the least amount of injury to alfalfa and red clover when compared to other herbicide treatments. The results of these studies illustrate the utility of imazapic for establishing mixtures of native grasses and legumes as well as managing invasive grass and broadleaf weeds in mixed stands.

CONVERSION OF TALL FESCUE TO WARM SEASON PRAIRIEGRASSES WITH IMAZAPIC. Thomas A. Hayden and Brian J. Dahlke, Field Biologists, BASF Corporation, Owensboro, KY 42301 and Seymour, IL 61875

Field Studies were conducted at three locations to evaluate tall fescue control with imazapic, glyphosate, imazapic + 2,4-D and imazapic + 2,4-D + glyphosate. Big bluestem, indiangrass and little bluestem were planted no-till after herbicide application. Tall fescue control was greatest at 78% from 0.188 lb/A of imazapic + 0.38 lb/A 2,4-D + 1.0 lb/A of glyphosate 13 months after treatment. Tall fescue control was 58% from 1.0 lb/A from glyphosate alone 13 months after treatment. Big bluestem stands were 50% or greater in the 0.188 lb/A imazapic + 0.38 lb/A 2,4-D or imazapic + 2,4-D + glyphosate treatments 13 months after herbicide application. Indiangrass stands were 41% with 0.188 lb/A imazapic + 0.38 lb/A 2,4-D + 1.0 lb/A glyphosate 13 months after treatments. Little bluestem stands were greatest at 35 to 36% in the 0.188 lb/A imazapic alone and 0.188 lb/A imazapic + 0.38 lb/A 2,4-D + 1.0 lb/A glyphosate treatments 13 months after treatment. Stands of big bluestem, indiangrass, and little bluestem were 19%, 10% and 14% respectively, 13 months after application of 1.0 lb/A glyphosate. Stands of big bluestem, indiangrass, and little bluestem were 12%, 10% and 2%, respectively, 13 months after application in the untreated check plots.

IMAZAMOX PLUS TANK-MIX PARTNERS FOR WEED CONTROL IN ALFALFA. David H. Johnson, Paul Ogg, Don Colbert, Gaylan Goddard, and Mauricio Britva. BASF Corp., St. Paul, MN, Longmont, CO, Lodi, CA, Yuma, AZ, and Research Triangle Park, NC.

Weed control and seedling alfalfa injury with imazamox applied alone and tank mixed with sethoxydim, clethodim, bromoxynil, or 2,4-DB were evaluated in Minnesota, Colorado, Arizona, and California in 2001. The use of imazamox on seedling alfalfa is not registered with EPA[1]. Imazamox was applied at 0.032 to 0.047 lb/a alone or tank mixed with the other herbicides to try to increase the weed spectrum and evaluate antagonism. All treatments contained crop oil concentrate and ammonium sulfate. Imazamox caused seedling alfalfa stunting at some locations, but the plants recovered rapidly. Adding sethoxydim, bromoxynil, or 2,4-DB increased injury slightly at some locations, and clethodim had no effect. Imazamox applied alone controlled most annual weeds present, including giant foxtail, woolly cupgrass, downy brome, lovegrass, common lambsquarters, flixweed, redroot pigweed, and hairy nightshade. Adding bromoxynil or 2,4-DB improved common waterhemp control to 100% and also improved goosefoot control compared to imazamox applied alone. No herbicide caused antagonism.

[1]The results presented in this abstract are for informational purposes only and are not intended to promote the use of imazamox other than as instructed in the currently approved EPA labeling. Any sale of the imazamox product shall be solely on the basis of the EPA approved product label and any claims regarding product safety and efficacy shall be addressed solely by the label.

GRADUATE EDUCATION: TRENDS AND PERSPECTIVE. Reid J. Smeda, Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211.

Opportunities for graduates in weed science have changed significantly over the past 20 years, likely in response to changes in herbicide development and use. Herbicide development has shifted from the use of predominantly PRE to predominantly POST compounds, contributing to decreases in the need for soil and environmental chemists. The number of novel herbicides peaked in the late 1980's; rising costs to develop new compounds has further led to reduced demand for chemists and biologists in screening compounds. With the lack of novel modes of action, herbicide physiologists have fewer opportunities to explore biochemical processes in plants in both academic and industry laboratories. One area that has seen unprecedented attention is weed biology and ecology. However, there are limited opportunities for students in academia and industry in this area. Recently, the emergence of biotechnology has somewhat resulted in consolidation of herbicides available for use in corn, but especially in soybean. This has devalued the herbicide market and has precipitated the merging and buyouts in the chemical company industry. Subsequently, the number of personnel in herbicide sales and technical service has been slashed over 50%. New graduates in weed science now face the merging of chemical and seed companies; additional skills needed to excel in this environment include genetics and plant breeding. All of these factors have reduced the attractiveness of weed science as a discipline to students making career choices. Those in academia training students are now experiencing greater difficulty in attracting domestic students to pursue graduate degrees in weed science. Weed science can survive as a discipline, but those training students must provide the broadest training possible and be attentive to the globalization and specialization of jobs in this area.

LESSON 101: THE SECRETS OF GRADUATE SCHOOL SUCCESS. Shannon M. Oltmans, Graduate Research Fellow, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

The 21st Century has brought many challenges to all facets of agriculture. Weed science graduate students are facing a declining agricultural economy and a changing field of study. The education that weed science graduate students received 10 to 15 years ago most likely was different than the education received by current graduate students. Weed science graduate students are encouraged to get a well-rounded education that includes more genetics and business courses and less biochemistry and soil science courses than their predecessors.

Components of many weed science graduate student projects include field, greenhouse, and laboratory research, with the attempt to provide them with opportunities to develop the knowledge, skills, and abilities needed for future careers. Coursework and research play a vital role in the satisfaction and success of graduate students; however, we cannot forget the influence of major advisors and student-advisor relationships. Friendly or professional relationships between major advisor and the graduate student generally provide an environment favorable for learning.

A survey of 19 questions was mailed to 100 students pursuing graduate degrees at 11 universities affiliated with the North Central Weed Science Society. The survey was aimed to identify areas that are meeting the expectations of graduate students, and areas that could use improvement. Questions addressed graduate student satisfaction with content of coursework, components of research, and involvement of the major advisor. Additional questions aimed to determine if graduate students feel the content of their coursework and components of research are successfully preparing them for their career. Results from this survey should indicate strengths and weaknesses in graduate student programs at universities affiliated with the NCWSS.

ACADEMICS, INDUSTRY OR OTHER – WHICH PATH DO I TAKE? Michael J. Horak, Monsanto Company, St. Louis, MO 63141.

One of the many decisions facing graduate students is selecting a career path upon graduation. There are a myriad of opportunities for well-trained weed science graduate students, and an important decision facing students is deciding which path to take first. Students are faced with deciding between the public and private sectors and the opportunities within each. Public sector positions may include university teaching, research and outreach positions, government research, regulatory and advisory positions, while private sector positions may include work with agricultural corporations, private research companies, consulting firms, to name a few. Since the career paths are many the question remains –which path do I take? In considering this question, it is important for an individual to take the time for personal evaluation and reflection and to seek input from trusted mentors. Thought and personal evaluation on questions such as “What are my long term career goals? What discipline within weed science do I most enjoy? What are my personal strengths and areas for growth? What has been my work experience and observation? What is my life focus, priorities?” can help an individual narrow the choices that may be the best fit for them. Evaluation of the opportunities and challenges of various jobs can also serve as a good exercise to help add clarity and focus to career path choices. Assessing various positions and the “big picture” responsibilities associated with the path may help add clarity. For example, in a university teaching or outreach position, a major thrust is education while in certain industry positions the development of useful products is the major focus. Discussing career paths with those already in similar positions will add critical insight. Other considerations may include lifestyles associated with positions (e.g. travel, benefits, salary, and the perception of “stability” etc.). Finally, it is important to remember that a first job is not necessarily the job from which a person will retire, rather it is an initial step, on a career path that may take many directional changes. Through personal evaluation and consideration of the career paths available, an individual can begin to make informed decisions that will direct them toward a fulfilling career.

TRANSITION FROM GRADUATE SCHOOL TO ACADEMIA. Bryan G. Young, Assistant Professor, Department of Plant, Soil, and General Agriculture, Southern Illinois University, Carbondale, IL 62901.

Transitions are life's challenges that dictate our success. For some graduate students an academic career is an attractive career path. The transition from graduate student to academia can be less stressful and possibly more successful if the student has realistic and known expectations for the academic career. A common perception is that an individual must be competent in three basic areas to be successful in an academic position: teaching, research, and communication. While this is true, an academic position entails several other challenges that may not always be perceived by a graduate student.

Graduate careers center around gaining experience through coursework, research, and interaction with fellow graduate students, faculty, and industry professionals. Their research is usually short term and very focused with a clear final goal of a thesis and publications. The initial stage of an academic career requires an individual to search for a long-term, sustainable field of research that can lead to professional success. One clear purpose of research is to produce publications. However, the requirements for the ultimate goal of attaining tenure can be less defined and will vary depending on the institution, department, and specific position appointment. The learning process must continue after graduate school to advance your competency in your selected research area. Instead of your competency being evaluated by a select few on a graduate committee, you are now being evaluated by your peers, sometimes on a national level. Making the conversion from student to teacher can also be a challenge. Although a graduate student entering an academic position may have a good working knowledge of statistics, it may be challenging to teach statistical applications to a graduate student advisee.

The transition to academia can be less intimidating if a graduate student is able to gain experience in the day to day duties of their advisor and takes an active role in learning about the processes of establishing a research direction and obtaining tenure. Even though assisting an advisor in tasks that are not directly associated with the student's thesis may seem unnecessary and inconvenient, the rewards will be evident once the transition to an academic position has occurred.

FROM DEFENDING A THESIS TO REPRESENTING A COMPANY: TRIALS AND TRIBULATIONS OF GRADUATE STUDENTS. Kaleb B. Hellwig, Technical Service Representative, BASF Corporation, Seymour, IL 61875.

Preparing graduate students for today and tomorrow presents many challenges to professors and their respective graduate students. There are many important topics to consider for a successful graduate school experience. Obtaining key skills and competencies will prepare graduate students for successful careers in today's challenging agriculture industry.

As a graduate student, setting and understanding goals with your major professor and graduate committee are an essential component to a successful graduate school experience. Goals will help determine a program of study and provide project focus. Identifying an expected career path after graduation may also determine many objectives for graduate student training.

Experience is valuable. Exploring opportunities to become more proficient in specific skills will better prepare students for a career in agriculture. Internships and other forms of work experience can provide excellent opportunities for students. One of the most beneficial methods of obtaining experience involves training for the North Central Weed Contest. Training and preparation for this contest educates contestants and applies student knowledge in herbicide symptomology, weed identification, sprayer calibration and applied problem solving. The "Problem-Solving" portions of the contest provide excellent preparation for "real world" customer service visits and an opportunity to analyze and diagnose crop production issues in the field.

Regardless of the career path, proficiency in communication, both oral and written, are very important. There are many opportunities to refine communication skills throughout graduate school. Presenting the results of experiments to various organizations are some of the most valuable. Some beneficial experiences may involve preparing written research reports, and oral presentations for university field days, crop diagnostic clinics, Weed Science Society meetings and seminar courses. Public speaking experience will be invaluable as students pursue employment. Graduate students and professors should take advantage of every opportunity to refine various types of written and oral communication skills.

Selecting courses that best educate students for a thesis defense and an agriculture industry career may present some challenges. Knowledge of specific subjects related to a graduate thesis project may be required for sufficient understanding of the topic. However, as the agriculture industry evolves and today's companies become more diverse, knowledge and understanding of many different aspects of agriculture business, crop production and crop pest management are essential. This background may be obtained through diversity of course work, internships or job experiences in both undergraduate and graduate studies. As the agriculture industry changes it is imperative to obtain a knowledge base in several core areas.

Understanding where crop production, and agriculture in general, will evolve may be one of the most important and difficult topics to understand. The ability to adjust and change with agriculture will be the most important challenge that professors, industry personnel and graduate students alike will need to continue to be successful in the future. Setting goals, gaining experience, and refining communication and scientific skills will better prepare graduate students for successful careers in agriculture industry of today and tomorrow.

ONE UNIVERSITY PROFESSOR'S PERSPECTIVE OF WHAT WEED SCIENCE GRADUATE STUDIES SHOULD INVOLVE. Stephen C. Weller, Professor, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907-1165.

Graduate education begins with the major professors' approach and philosophy of what student training should involve. Advisors must provide the advice and opportunity for students to prepare themselves for the challenges they will face in their careers. A graduate program should be designed to fit the student's desires in for their career path of choice. An adviser should provide a realistic view of how the student can best prepare for professional life after graduate school. This is accomplished by making sure that each student knows they are special, and feels free to discuss weeds science questions at all times. Prior to entering a graduate studies program, a student should ask a potential graduate advisor to articulate their graduate studies philosophy as the answer can be invaluable for the student in deciding where to attend graduate school.

Graduate education in weed science should challenge students through a broad variety of experiences in the classroom, laboratory and field. A broad approach to education fosters more comprehensive professional growth. Students become more aware of practical weed science questions that need to be addressed and develop a clearer perspective of research areas at both the practical and basic levels. Weed science students need a broad perspective of basic and applied agriculture as well as the basic sciences. It is important that the student, especially at the Ph.D. level have a passion for research and education. In addition, regardless of whether the student is a terminal Master of Science (MS) or a Doctor of Philosophy (Ph.D.) student; classroom experiences are vital to future success. Course work should include basic biology, plant physiology, plant ecology, chemistry, biochemistry, molecular biology, genetics and statistics with studies in pest management and crop production systems. During the Ph.D. degree, additional in-depth coursework beyond the basics is possible.

The research portion of a degree should prepare the student for many and varied career opportunities. Most students will not remain in the same job for their entire career. I prefer that MS students conduct research that provides experiences in both the field and laboratory to allow each student to grasp differing challenges each type of research presents. Ph.D. students are more likely to concentrate on in-depth study involving primarily laboratory or field research. The Ph.D. program is meant to develop capabilities for a research career and prepares one to ask more fundamental questions relating to science. The Ph.D. program is usually followed by post-doctoral work to further refine a person into a solid scientist; however, in weed science, some new Ph.D's are still hired immediately into government, universities or industry research jobs. In all these instances, a broad education allows a student to be better prepared to face a wider variety of career opportunities and be more flexible in their career.

The best forum for additional career preparation are shared experiences of students and professors in seminars, laboratory meetings and participation in field days, state, regional, and national meetings. Students must be included in writing research reports, scientific papers and if possible research grants. Such experiences aid students in observing weed science in a broader perspective and better prepares them for the future.

OPTIMUM USE OF SULFENTRAZONE IN SUNFLOWER. Gregory W. Kerr, Phillip W. Stahlman, and J. Anita Dille, Graduate Student, Professor, and Assistant Professor, KSU Agricultural Research Center, Hays, KS 67601, and Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Weed control in reduced tillage and no-tillage sunflower cropping systems is limited by a lack of herbicides not requiring incorporation. Sulfentrazone received Section 18 Specific Exemption registration each of the past three years for use in reduced tillage, conservation tillage, and no-tillage sunflower fields. Numerous occurrences of sunflower injury in 1999 seemed related to one or more factors including time of herbicide application, high herbicide rate on some soils, and seeding depth. Experiments were conducted in a greenhouse and at three field sites in western Kansas in 2000 and 2001 to evaluate effects of herbicide rate, time of herbicide application, and seeding depth on sunflower tolerance to sulfentrazone. Sunflower were seeded 2 or 4 cm deep and sulfentrazone was applied preemergence at 0, 140, 210, or 280 g/ha in greenhouse experiments, whereas in field experiments sunflower were seeded 2 or 3 cm deep and sulfentrazone was applied preemergence at 0, 105, 140, 158, and 210 g/ha. Companion experiments were conducted at field site in which sulfentrazone at each rate was applied approximately 45, 30, or 15 days preplant as well as preemergence. Rainfall delayed seeding at one site resulting in timings of 52, 39, and 24 days preplant.

Sulfentrazone stunted sunflower plants in greenhouse and in four of eight field experiments, but injured plants in field experiments recovered and seed yields did not differ between sulfentrazone rates. Sunflower plant dry weights as a percent of the untreated control decreased in greenhouse experiments and visible injury generally increased in field experiments as sulfentrazone rate increased. Averaged across herbicide rates, increased seeding depth increased plant dry weights in the greenhouse and reduced stunting in the field. Increased seeding depth also increased sunflower yield averaged across herbicide rates in 2000 but not in 2001. Early preplant application of sulfentrazone reduced sunflower stunting compared with preemergence application, but less injury achieved with preplant application did not result in higher seed yield. These studies indicate lowering use rate, applying sulfentrazone 15 to 45 days preplant rather than preemergence, and increasing sunflower seeding depth can lessen risk of sunflower injury to sulfentrazone.

HERBICIDES SPLIT-APPLED FOR WILD OAT CONTROL IN HARD RED SPRING WHEAT. Sam J. Lockhart and Kirk A. Howatt, Graduate Research Assistant and Assistant Professor, North Dakota State University, Fargo, ND 58105.

Interference from wild oat is a major problem in North Dakota hard red spring wheat production. Early emerging wild oat plants are the most competitive with the wheat crop, so both early and full season control of wild oat is critical for reducing wild oat interference to hard red spring wheat. Field experiments were conducted at Fargo and Grandin, ND, in 2000 and 2001 to evaluate clodinafop, fenoxaprop-P, flucarbazone-sodium, and tralkoxydim at labeled and reduced rates for wild oat control, wild oat seed rain and wheat yield. Each herbicide was applied once at 25, 33, and 100% of the labeled wild oat rate to 2-true-leaf wild oat plants. Split-applied treatments totaled 50% and 67% of the full rate, divided into two equal applications, and were applied at the 2-true-leaf wild oat stage and 10 days later.

Excellent full-season wild oat control was obtained with two reduced-rate treatments of clodinafop, flucarbazone-sodium, and tralkoxydim. Wild oat control was significantly less than the full rate with single reduced-rate treatments of clodinafop, tralkoxydim, flucarbazone-sodium, and fenoxaprop-P. Tralkoxydim or clodinafop split-applied at 25% and 33% rates per application provided wild oat control equal to labeled rates. Fenoxaprop-P and flucarbazone-sodium split-applied at 33% rate provided control equal to labeled rates. Wild oat seed rain was limited and similar among all herbicide treatments, except fenoxaprop-P single applied at 25% and 33% rates, which were 47% of untreated plots. Wheat yields were highest and similar following treatment with clodinafop and tralkoxydim when applied either once at the labeled rate or split-applied at 25% or 33% rates (total equaled 50% and 67% of full rate).

WILD OAT CONTROL IN SPRING WHEAT. Stephen D. Miller, Craig M. Alford and Roger Hybner; Professor, Research Scientist, and Superintendent; Department of Plant Sciences and Sheridan Research and Extension Center; University of Wyoming, Laramie, WY 82070.

Wild oat (Avena fatua L.) is a serious grassy weed problem in spring seeded barley and wheat production areas of the Northern Great Plains. It is estimated that wild oats cost small grain producers in this area over $180 million annually. Wild oat herbicide performance varies dramatically with climatic conditions, application timing and plant growth conditions. Research was conducted at the Research and Extension Center, Sheridan, WY in 2000 and 2001 to evaluate wild oat control and spring wheat response with six herbicide treatments applied at three application timings. Plots were 10 by 30 ft. and were arranged in a randomized complete block design with three replications both years. All treatments were applied with a CO_2 pressurized knapsack sprayer. Treatments applied at the two-leaf stage of wild oat provided better wild oat control and higher crop yields than treatments applied at the six-leaf stage. Clodinafop was the only treatment that provided excellent wild oat control at all application timings in 2000, while MKH-6562 was the only treatment to do the same in 2001. Slight injury was observed with clodinafop at the two-leaf application timing in 2000 and moderate injury observed with MKH-6562 at the six-leaf application timing both years.

AE F130060 - A NEW SELECTIVE HERBICIDE FOR GRASS CONTROL IN WHEAT. Dean W. Maruska, Technical Development Representative, Aventis CropScience RTP, NC 27709.

AE F130060 combined with mefenpyr-diethyl, a safener in a 5:1 ratio is a new postemergence herbicide being developed by Aventis CropScience for weed control in wheat. AE F130060 is comprised of the active ingredient mesosulfuron-methyl. This herbicide acts as an inhibitor of acetolactate synthase (ALS). Mesosulfuron-methyl will control many important grass weeds in wheat and is highly active on wild oats, Bromus sp. and annual ryegrass as well as some broadleaf weeds such as wild mustard. Mefenpyr-diethyl is a postemergent safener registered for use on wheat and barley in the United States and Canada. AE F130060 plus mefenpyr-diethyl exhibit excellent wheat tolerance at 2.5 to 15 g ai /ha.

In field experiments in North America, mesosulfuron-methyl controlled annual ryegrass, annual bluegrass, wild oat, canarygrass, downy brome and Japanese brome as well as wild mustard, Tansy mustard and blue mustard. AE F130060 is applied to grass weeds up to 2 tiller in size and 1-2 leaf mustards. Best weed control is achieved when a NIS or MSO at .25 - .5% v/v is added to the tankmixture.

AE F130060 has a very favorable ecological, ecotoxicological and environmental profile with low acute mammalian toxicity and no genotoxic, mutagenic or oncogenic properties noted. Microbial degradation is the primary degradation pathway of mesosulfuron-methyl in the environment. Mesosulfuron-methly is rapidly degraded and unlikely to pose any risk to succeeding crops. Excellent control of acc-ase resistant wild oat (Avena fatua L.) biotypes have been attained with AE F130060 in field trials. AE F130060 also controls diclofop resistant annual ryegrass (*Lolium multiflorum* L.).

The low use rate, excellent weed control and crop safety combined with very favorable toxicological, ecotoxicological and environmental properties will make this product a valuable tool for wheat farmers.

THE USE OF AE F130060 HERBICIDE FOR GRASS CONTROL IN WHEAT. Kevin B. Thorsness, Monte D. Anderson, William Bertges, Charles P. Hicks, Kelly Luff, Marc Hoobler, Dean W. Maruska, Jack Otta, Mary Paulsgrove, and Michael Smith, Technical Development Representatives, Aventis CropScience, Research Triangle Park, NC 27709.

Control of grassy weeds in wheat is an important aspect of cereal production in the northern wheat producing area of the United States. NDSU research has shown that wild oat and foxtail populations of 172 plants/m^2 will reduce spring wheat yields approximately 40 and 15%, respectively.

AE F130060 WDG60 plus AE F107892 at a 1:6 ratio is a new postemergence herbicide that is being developed by Aventis CropScience. AE F130060 WDG60 is composed of AE F130060 plus AE F115008 at a 5:1 ratio. The proposed common name for AE F130060 is mesosulfuron-methyl, it is active on wild oat, foxtail species, ryegrass, and bromus species. The proposed common name for AE F115008 is iodosulfuron-methyl-sodium, it is active on several broadleaf weed species. The common name for AE F107892 is mefenpyr-diethyl, it is a multi-herbicide postemergent safener registered on for use wheat and barley in the United States and Canada.

The objectives of this research were; 1) evaluate AE F130060 WDG60 plus AE F107892 for tolerance in spring wheat and 2) evaluate AE F130060 WDG60 plus AE F107892 for grass control in spring wheat. Tolerance trials and wild oat and foxtail trials were conducted at several sites in North Dakota, Minnesota, and South Dakota in 2001. In the wheat tolerance trials, percent visual injury was determined approximately 10 and 30 days after treatment (DAT) and at pre-harvest. Wheat yield was also determined. In the weed control trials, percent visual weed control was determined approximately 30 DAT and at pre-harvest.

Percent visual crop injury 7-12 DAT and averaged over locations was acceptable with AE F130060 WDG60 plus AE F107892 at 5 plus 30 g ai/ha, regardless of adjuvant systems or wheat stage at application. However, the methylated seed oil plus 28% nitrogen adjuvant system compared to the basic blend adjuvant system significantly increased wheat injury. Also, wheat injury was significantly greater with methylated seed oil or methylated seed oil plus 28% nitrogen adjuvant system compared to the nonionic surfactant adjuvant system. Wheat yield was not negatively influence by the visual injury symptoms that were observed.

Percent visual wild oat control with AE F130060 WDG60 plus AE F107892 at 2.5 plus 15 g ai/ha was significantly greater with the methylated seed oil adjuvant system than either the nonionic surfactant or crop oil concentrate adjuvant systems at pre-harvest assessments. Wild oat control was significantly increased with the basic blend adjuvant system compared to the crop oil concentrate adjuvant system. AE F130060 WDG60 plus AE F107892 at 2.5-7.5 plus 15-45 g ai/ha gave similar wild oat control at 93-98%. However, green foxtail and yellow foxtail control at these same rates was 58-61% and 68-82%, respectively. Tank mixing various broadleaf herbicides with AE F130060 WDG60 plus AE F107892 at 5 plus 30 g ai/ha did not significantly antagonize wild oat control.

WEED CONTROL AND CROP TOLERANCE TO FLUCARBAZONE. Krishona L. Martinson, Beverly R. Durgan, and Jochum J. Wiersma, Research Associate, Professor and Assistant Professor, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108.

Flucarbazone is a new postemergence grass herbicide for use in spring wheat. Flucarbazone must be tank-mixed with a recommended surfactant and a broadleaf herbicide for broad-spectrum activity and crop safety. The objective of this study was to evaluate wild oat and foxtail control and wheat tolerance to flucarbazone. The experiment was conducted in Crookston and Rosemount, Minnesota in 2000 and 2001. "2375" wheat was seeded at 1.5 Bu/A and flucarbazone was applied at the 3-4 leaf stage for wild oat and the 2-4 leaf stage for foxtail. Flucarbazone was applied with the recommended rates of the following broadleaf herbicides: 2,4-D amine, 2,4-D ester, bromoxynil, carfentrazone, fluroxypyr, MCPA ester, thifensulfuron and tribenuron. All tank-mixes were applied with 0.25% NIS. The experimental design was a randomized complete block with three replications and the plot size was 10' by 16'. Crop injury and weed control were visually rated at 7, 14, and 21 DAT and crop yields were taken. Means were separated using Fisher's Protected LSD at the 5% level of significance. Flucarbazone tank mixes did have early (7 DAT) visual crop injury. However, this early visual injury was undetectable at 21 DAT and did not result in a yield reduction for all but one treatment. The tank-mix of flucarbazone + thifensulfuron + fluroxypyr + NIS did have a significant reduction in yield. Flucarbazone tank-mixes did result in acceptable control of wild oat and foxtail. Weed control was visually rated at 95 to 99% for both wild oat and foxtail. In conclusion, flucarbazone tank-mixes are a safe and effective way to control wild oat and foxtail in spring wheat.

APPLICATION FACTORS AFFECT PROPOXYCARBAZONE AND SULFOSULFURON PERFORMANCE IN WHEAT. Patrick W. Geier and Phillip W. Stahlman, Assistant Scientist and Professor, Kansas State University Agricultural Research Center, Hays, KS 67601.

Effects of spray solution and application timing on downy brome control and crop tolerance in winter wheat were evaluated in a field study near Hays, KS in 2001. Herbicides were applied postemergence in water (100%), urea-ammonium nitrate (UAN) (100%), or a mixture of UAN and water (50:50%) in fall or early spring. Propoxycarbazone at 0.04 lb/A and sulfsosulfuron at 0.031 lb/A were applied alone and plus chlorosulfuron&metsulfuron or triasulfuron in fall, and alone and plus chlorosulfuron&metsulfuron or triasulfuron&dicamba in spring. All treatments included nonionic surfactant at 0.25% v/v. Spray solutions without herbicide were applied as controls at each time of application. There was no spray solution by herbicide interaction for downy brome control, nor were differences among spray solution main effects significant. In late March, averaged over spray solutions, fall-applied propoxycarbazone plus chlorosulfuron&metsulfuron or triasulfuron controlled downy brome more than propoxycarbazone alone; however, control was similar by the end of May. In contrast, tank mixtures were slightly less effective than propoxycarbazone alone when applied in spring. Downy brome control was not improved by tank mixing with sulfosulfuron compared to sulfosulfuron alone at either time of application. Sulfosulfuron controlled downy brome slightly more than propoxycarbazone when applied in fall, whereas propoxycarbazone was the more effective when applied in spring. Downy brome control averaged about 20% and 30% higher, respectively, when propoxycarbazone and sulfosulfuron treatments were applied in fall compared with applications in spring. Herbicides applied in 50% and 100% UAN in fall caused 11 to 15% and 25 to 28% foliar burn, respectively, at 7 DAT. Herbicides applied in spring caused little foliar burn, but most tank mixtures stunted wheat growth, delayed wheat maturity, and shortened the height of mature wheat compared to wheat receiving spray solutions without herbicide; herbicides applied in fall caused no such effects. Fall-treated wheat yielded 17 to 20 bu/A more grain than nontreated wheat, and 11 to 14 bu/A more than wheat treated in spring. Wheat yields were slightly lower when treatments were applied in 50% or 100% UAN compared to water.

WEED CONTROL AND CROP TOLERANCE IN GLYPHOSATE RESISTANT WHEAT. Sarah M. Kaping, Beverly R. Durgan, Krishona L. Martinson, and Jochum J. Wiersma, Research Associate, Professor, Research Associate, and Assistant Professor, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108.

Two field experiments were conducted to determine weed control and crop tolerance in glyphosate resistant Hard Red Spring Wheat (HRSW) at Crookston, Minnesota in 2001. To determine the crop tolerance to glyphosate, a glyphosate resistant line derived from the HRSW cultivar ‘Oxen’ was seeded at 1.5 Bu/A. The experimental design was a randomized complete block with three replications and the plot size was 10’ by 16’. Crop injury and weed control were visually rated at 7, 14, and 21 DAT and crop yields were taken. Means were separated using Fisher’s Protected LSD at the 5% level of significance.

To evaluate weed control and crop tolerance of the glyphosate resistant HRSW cultivar derived from ‘Oxen’ to tank mixing glyphosate with other postemergence herbicides, glyphosate was tank mixed with fenoxaprop, clodinafop, flucarbazone, bromoxynil, dicamba, tribenuron, and 2,4-D + clopyralid. The postemergence grass and broadleaf herbicides were applied to weed free plot of the glyphosate resistant line at labeled rates and the appropriate timing of application. Herbicides evaluated included: glyphosate, fenoxaprop, clodinafop, flucarbazone, bromoxynil, dicamba, tribenuron, and 2,4-D + clopyralid. Broadleaf and grass weed control was good to excellent with all herbicide treatments. Weed control was visually rated at 95 to 99% for green and yellow foxtail, wild mustard, common lambsquarters and smartweed. Crop tolerance of the glyphosate resistant line derived from ‘Oxen’ was good to excellent.

In summary, glyphosate when applied alone and in tank mixes with other postemergence grass and broadleaf herbicides labeled for use on HRSW to glyphosate tolerance HRSW provided effective grass and broadleaf weed control and excellent crop safety. No interactions between the glyphosate and the other postemergence herbicides for either weed control or crop tolerance were detected. Sarah Kaping 411 Borlaug Hall University of Minnesota St. Paul, MN 55108 (612) 625-8700. kapi0011@tc.umn.edu

IMIDAZOLINONE RESISTANT PRODUCTION SYSTEM – IMAZAMOX HERBICIDE FOR WINTER WHEAT. James F. Gaffney, Kenneth L. Carlson, Mark C. Boyles, Brian J. Dahlke, Paul J. Ogg, and Gary M. Fellows, Field Research Biologist, BASF Corporation Seymour, IL 61875, Lincoln, NE 68506, Ripley, OK 74062, Seymour, IL 61875, Longmont, CO 80503, and Research Triangle Park, NC 27709.

Field trials demonstrate that imazamox herbicide provides a novel approach to controlling broadleaf and grass weeds in imadazolinone resistant winter wheat. These weeds include jointed goatgrass and feral (volunteer) rye, weeds not previously controlled with existing herbicide programs. Other grasses controlled include wild oats, cheat, Japanese brome, downy brome, Italian ryegrass, Persian darnel, and volunteer spring and winter cereals. Additionally, imazamox controls many winter and summer annual broadleaves. Imazamox with a variable application rate of 0.032 to 0.048 lbai/A, was applied in field trials in fall or spring to imadazolinone resistant winter wheat from the 3-leaf to prejoint stage. The variable rate allows for precision application based on weed targets and application sizes. Imidazolinone resistant wheat tolerance at 2x rates of imazamox application was excellent. Field trials demonstrate that economic benefits include reduced weed competition, higher yields, and less weed seed contamination of the crop. Ease of tankmixing with imazamox has also been demonstrated in field trials, allowing resistance management options and management of more difficult to control weeds. Imazamox offers a wide range of followcrop flexibility for crop rotation in all geographic areas of the United States. Efficacy data from over seven years of field research trials, both at universities and with BASF researchers have demonstrated that imadazolinone resistant winter wheat and imazamox herbicide comprise an excellent weed control system. Imazamox herbicide is not yet registered for use within the United States on imidazolinone resistant winter wheat. Registration is anticipated in the fourth quarter of 2001.

WINTER ANNUAL GRASS CONTROL AND RESPONSE OF IMIDAZOLINONE-RESISTANT WINTER WHEAT TO IMAZAMOX. Phillip W. Stahlman, Patrick W. Geier, and Troy M. Price, Professor and Assistant Scientist, KSU Agricultural Research Center, Hays, KS 67601, and Assistant Scientist, Northwest Research-Extension Center, Colby, KS 67701. (190)

Three field studies were conducted near Hays and Colby, Kansas in 2000-2001 to evaluate winter annual grass control and winter wheat response as affected by imazamox rate and time of application. Additionally, a single study was conducted near Hays to determine if the amount of liquid nitrogen in the spray solution affected weed control and crop response. Jointed goatgrass was present in all studies and downy downy brome was present in each study at Hays. In the first study, imazamox at rates of 0.032, 0.040, or 0.048 lb ai/A plus 2% urea-ammonium nitrate (UAN) and 1% methylated seed oil (MSO) was applied in water at each of four times: early fall POST (EFP), late fall POST (LFP), early spring POST (ESP) or late spring POST (LSP). Imazamox, regardless of rate, controlled jointed goatgrass and downy brome 98% or more when applied in fall. When applied in spring, jointed goatgrass and downy brome were controlled at least 96% in Hays studies, but jointed goatgrass control at Colby ranged from 90 to 95% for ESP treatments and 72 to 80% for LSP treatments. Spring-applied imazamox reduced the growth of wheat by up to 33% at Hays but no growth reduction was observed at Colby at any rate or timing. Growth reduction at Hays increased with increasing imazamox rate and later application. However, there was no rate by timing interaction for wheat yield in any of the three experiments. Averaged over time of application, wheat treated with imazamox at 0.032 or 0.040 lb/A produced similar or higher yields than wheat treated with the 0.048 lb/A rate. Averaged over imazamox rate, fall-treated wheat yielded similarly or more than wheat treated ESP, which in turn yielded considerably more than wheat treated LSP. In the second study, imazamox plus 2% UAN and 1% MSO applied in water controlled jointed goatgrass, downy brome, or feral rye 97% or more, regardless of imazamox rate, spray solution, or time of application. Though the amount of nitrogen in the spray solution did not affect weed control, the wheat was affected. Fall-applied UAN (30 lb N/A) without imazamox or adjuvant caused 22% foliar burn at 13 DAT compared to 7% foliar burn when diluted 50% with water. Including imazamox and MSO in each spray solution further increased foliar burn 10 to 15%. However, wheat recovered fully in about 3 weeks and yields were not affected.

FERAL RYE CONTROL IN IMI-TOLERANT WINTER WHEAT. Stephen D. Miller and Craig M. Alford, Professor and Research Scientist, Department of Plant Sciences, University of Wyoming, Laramie, WY 82070.

Feral rye (Secale cereale L.) is a winter annual grassy weed which is rapidly spreading in the winter wheat areas of the high plains of Colorado, Nebraska and Wyoming. The spread of this weed has been rapid in recent years responding favorably to changes in farming practices (i.e. conservation tillage, short stature wheat and increased fertilizer application). Recent surveys in Colorado indicate that this weed causes economic losses in excess of $10 million annually. Not only is this weed competitive with winter wheat, but wheat seed contaminated with feral rye produces flour with poor baking characteristics. Field experiments were conducted in southeastern Wyoming from 1998 to 2001 to evaluate feral rye control and rotational crop response to imazamox in imi-tolerant (Clearfield) winter wheat. Feral rye control generally increased as imazamox rate increased from 0.032 to 0.04 lb/A and was better with early fall (2 to 4-leaf with <2 tiller) compared to late fall or early spring applications (4 to 6-leaf with 2 to 6 tillers). Imi-winter wheat tolerance has ranged from marginal to excellent and appears to be influenced by cultivar, environment and spray additive. In emergency plant back trials (loss of crop to hail or other factors in the spring) standard corn and sunflower were injured by imazamox applications made 2 to 6 months earlier in winter wheat. However, when these crops were seeded in a normal rotational cropping sequence (13 to 18 months following application in winter wheat) both crops exhibited excellent tolerance.

WEED SCIENCE TRAINING AT CORN/SOYBEAN EXPOS AND SOYBEAN MANAGEMENT FIELD DAYS. Robert N. Klein and Alex R. Martin, Professors, University of Nebraska, North Platte, NE, and University of Nebraska, Lincoln, NE.

Research has shown that an audience remembers only about 10% of what it hears. The learning experience greatly increases if the audience participates. In the past, the weed science training consisted of the usual 20 to 30 minutes lecture with slides. At the Corn/Soybean EXPO's in 2001 we changed the format to one-hour sessions emphasizing four areas. We wanted the audience involved as active participants. The weed science session was called, "How to put together a cost efficient weed management program". "Pesticide Application - Nozzle tip selection, sprayer setup, reducing drift, and increase sprayer efficiency" was another one of the four sessions. A pre-test and post-test were given on the four areas with the participants greatly increasing their knowledge in all areas. The format used in the sessions was as follows: the presenter gave the participants information and a problem to work on in groups of 4 to 6. Then the groups were asked to discuss their answers with the audience. The application section dealt with having boxes of nozzle tips, literature and a demonstration. The Soybean Management Field Days also had one hour sessions and these Days were held on farms. Those attending were presented a weed management problem and divided into groups the same as at the Corn/Soybean EXPO's. These sessions were concluded with a tour of plots established to demonstrate the various weed control measures discussed. In summary, the idea was to get the audience involved in the activity.

APPLYING COMPUTER TECHNOLOGY IN WEED SCIENCE EXTENSION EDUCATION. Kelly J. Goedde, Thomas T. Bauman, and Merrill A. Ross, Graduate Research Assistant, Professor, and Professor, Department of Botany and Plant Pathology, Stephen C. Weller, Professor, Department of Horticulture and Landscape Architecture, Gregory L. Willoughby, Director of Crop Diagnostic Training and Research Center, Department of Agronomy, Purdue University, West Lafayette, IN 47906, and Case R. Medlin, Assistant Professor, Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK 74078.

The American Society of Agronomy (ASA) with assistance from agribusiness retailers, dealers, manufacturers, and Cooperative Extension personnel created a qualification standard for professionals who serve as consultants to farmers and other agriculture clientele [i.e. the Certified Crop Advisor (CCA) program]. To become a CCA, agricultural professionals must first pass a rigorous exam testing their knowledge in four areas; soil fertility, soil and water management, integrated pest management (IPM), and crop management. The program also requires CCAs to maintain their qualification by earning Continuing Educational Units (CEUs) in one of four competency areas. In each of the four areas one earn must ten CEUs every two years in order maintain certification.

Purdue is creating online modules to assist people in-training for the exam and for currently certified CCAs to earn CEUs. Much of the material will also be available online as reference material for the public. Offering online modules will help the CCA program achieve its mission of improving environmental stewardship within the agriculture sector. The weed science modules will include a seed database for identification based on distinguishing characteristics or morphology (size, color, shape, or special characteristics). Computer rendered drawings will illustrate seed anatomy and aid in the selecting the criteria needed to perform a search. By selecting criteria of a seed, one will narrow the database to a few records. On-line help images and selection criteria will assist in problem solving by narrowing response possibilities from over 200 weed species currently housed in database. The ultimate goal will be to simply narrow the search so the user will make the final diagnosis from the resulting possibilities.

Herbicide mode of action modules will be available as educational tools and informational resources for agricultural professionals studying for the exam. Technical and non-technical descriptions will be used to educate a wide range of readers about various herbicide families mode of action of the herbicide family. Non-technical descriptions will explain the symptomology of a mode of action and where is the herbicide’s site of action. Technical descriptions of each mode of action will have more detailed explanations of the biochemical pathways affected and mechanisms that cause plant death. Symptomology images and time-lapse videos of each herbicide family will also illustrate details of each mode of action. Non-technical summaries will be available online for unrestricted use while certain technical information will be accessible only to CCAs wishing to earn CEUs.

EXPLAINING HERBICIDE RESISTANCE TO A NON-SCIENTIFIC AUDIENCE. Chad D. Lee, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Herbicide mode of action and herbicide resistance can be complex concepts to scientific audiences and even more challenging to non-scientific audiences. The complexity of these topics can hinder the discussion of herbicide resistance in weeds and herbicide resistance management. To explain the concept of herbicide resistance to the non-scientific audience, several illustrations have been developed within the MicroSoft PowerPoint program. An animated drawing of a tractor is used to illustrate an enzyme molecule. A drawing of a board with spikes is used to illustrate an herbicide molecule. The binding site of the herbicide is the rubber tire of the tractor. A single point mutation that affects the binding site but does not hinder the function of the tractor (enzyme) is illustrated by changing the rubber tires into a track. Thus, the tractor with tires is considered to be a susceptible enzyme while the tractor with tracks is considered to be the resistant enzyme. By illustrating that the tractor with tracks is resistant to the board with spikes, the non-scientific audience is shown how sites of action within a plant can resist an herbicide molecule. The illustration has also been modified to provide a very general explanation of multiple gene resistance, which usually involves a metabolism-based resistance. In this scenario, the tractor with tires (herbicide binding site) does not change. However, another machine carrying a magnet removes the board with spikes. These illustrations provide an effective starting point for discussing herbicide resistance with a non-scientific audience.

USE OF REMOTE SENSING TO DETECT HERBICIDE INJURY IN SOYBEAN. Kurt D. Thelen and Chad Lee, Assistant Professor and Extension Specialist, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Multi-spectral imagery was evaluated as a tool for detecting herbicide injury in soybean. Three methods of collecting canopy light reflectance data were utilized including a ground based sensor, an airplane mounted camera, and satellite images. Herbicide injury was induced by applying 0, 1, 2 and 4x rates of lactofen and imazethapyr. Normalized differential vegetation indices were linearly correlated with lactofen and imazethapyr application rate. Correlation coefficients ranged from 0.67 to 0.97. Cloud cover was problematic for collecting aerial and satellite canopy reflectance data and would likely be a practical limitation in the North Central Corn Belt.

SOLVING CROP INJURY SITUATIONS AND PREPARING FOR LITIGATION. Bernard H. Zandstra, Professor, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Weed scientists are often called upon to help solve crop injury situations. Crop injury can result from drift, carryover, incorrect rate, incorrect timing, use of unregistered or inappropriate products, adverse weather, improper application, or unexplained causes. It is the responsibility of a technical expert to evaluate the situation and help determine the cause of the problem and extent of the crop injury. Weed scientist testimony may be required to set a value on the loss or, in case of litigation, may be the critical factor in reaching a settlement.

Extension Specialists and researchers are considered to be objective experts. Their input, knowledge, and experience is critical in reaching a satisfactory and fair conclusion. When acting in their capacity as public employees, they should maintain strict neutrality in injury cases to avoid an impression of bias.

Complete documentation of the situation is critical to support your position. Photographs of the injury, spray records, weather records, crop yield and price data, and interviews with persons involved will help support your conclusions. Extensive knowledge of the crop and herbicides involved will add credibility and help solve the situation.

A final report should include information that is supportable through observation and experience. Be prepared to defend anything you write or say in a court of law.

CONTROL OF COMMON DANDELION WITH GLYPHOSATE AS AFFECTED BY APPLICATION TIMING. Aaron S. Franssen* and James J. Kells, Graduate Research Assistant and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Common dandelion (*Taraxacum offinale*) is a troublesome weed in continuous no-till, glyphosate-resistant corn and soybean in Michigan, especially when glyphosate is the primary herbicide. Glyphosate-resistant corn and soybean field experiments were initiated in 2001 to evaluate the effect of application timing on the control of common dandelion with glyphosate and 2,4-D ester. Corn and soybean experiments were conducted on no-till fields with established populations of common dandelion on two separate sites (Mason and Corunna) in southern Michigan. Glyphosate applied with 2% ammonium sulfate (AMS), 2,4-D ester, and glyphosate+2,4-D ester applied with 2% AMS were applied at several times through the growing season.

Glyphosate-resistant corn was planted into soybean residue in 76 cm row spacing. Treatments were applied early preplant (EPP), preemergence (PRE), and at two timings after crop emergence. The early post (EPOST) application was applied to 2-3 collar corn and the late post (LPOST) application applied to 5-6 collar corn. Glyphosate applied EPP and EPOST at 843 g ae ha^{-1} provided 87 and 77 percent common dandelion control, respectively. Common dandelion control with 2,4-D ester applied EPP was less than 30 percent.

Glyphosate-resistant soybeans were planted into corn residue in 19 cm row spacing. Similar timings were applied in soybeans as in the corn trial. Glyphosate applied PRE at 843 g ae ha^{-1} provided 77 percent control while 2,4-D ester applied EPP provided 71 and 86 percent control; at 427 g ai ha^{-1} and 562 g ai ha^{-1}, respectively.

PASTURE WEED MANAGEMENT ISSUES FOR HORSES AND CATTLE IN DANE COUNTY.

David W. Fischer, Crops and Soils Agent, UW-Extension Dane County, Madison, WI 53718.

Demand has increased for pasture management information in Dane County. Much of this increase is in direct response to the increased number of horses. Many of the horse owners have little or no knowledge on pasture management techniques. In addition, all are concerned about the possibility of poisonous weeds being present in their pasture. While some of my time has been spent evaluating these pastures for the presence of poisonous weeds, more time has been spent educating owners on what they can do to prevent weed problems.

The first weed that is looked for in Dane County horse pastures is hoary alyssum. A member of the mustard family, hoary alyssum can be found in localized pockets throughout the county and is possibly one of the most toxic weed species to horses that is found in Dane County. While I have not seen hoary alyssum in pastures, numerous other weed species have been found. Smallflower buttercup was found in one new pasture at densities exceeding 10 plants per square foot. Recommendations include ensuring adequate alternative feed being available during the spring and dormant alfalfa treatment to reduce the potential for poisoning.

Other common weed species found that if overgrazed could cause problems included redroot pigweed, jimsonweed, eastern black nightshade, foxtail spp., common lambsquarters, and curly dock. All of these weed species can easily be controlled via proper pasture management practices such as not over-grazing. Two plant species found in Dane County that can be extremely toxic to livestock and horses are poison hemlock and water hemlock. However, both are difficult to find and have very low palatability.

The main factor in controlling weeds in Dane County pastures is to properly manage the grazing of the cattle or horses. This includes resting pasture during hot dry periods, releasing animals to new pastures on a full stomach, and ensuring adequate feed is available at all times.

WEEDSOFT: A REGIONAL WEED MANAGEMENT DECISION SUPPORT SYSTEM. Alex R. Martin* and Lynn B. Bills, Professor-Extension Weed Specialist and Visual Basic Program Weed Science, Department of Agronomy and Horticulture, University of Nebraska, Lincoln, NE, 68583, David A. Mortensen, Associate Professor-Weed Ecologist, Department of Crop and Soil Sciences, Pennsylvania State University, University Park, PA, 16802, Chris M. Boerboom, Extension Weed Specialist/Associate Professor, Department of Agronomy, University of Wisconsin, Madison, WI, 53706, and William G. Johnson, Assistant Professor and State Extension Specialist-Weed Science, Department of Agronomy/Plant Sciences Unit, University of Missouri, Columbia, MO, 65211.

WeedSOFT, a Windows based weed management decision support system originally developed at the University of Nebraska is now being modified for use in seven North Central states. This effort will result in each cooperating state having a version of WeedSOFT, that addresses its unique soil and climatic conditions, weed species and crop production practices. This regional project involves Illinois, Indiana, Kansas, Michigan, Missouri, Nebraska and Wisconsin. WeedSOFT consists of two modules, Advisor and MapVIEW. Advisor supports preemergence, postemergence and pre + postemergence weed management decisions in four crops: corn, sorghum, soybean, and wheat. WeedVIEW provides visual images as an aid in weed identification.

Advisor computes a crop yield loss and dollar loss based on weed density, weed free yield goal, and expected crop price. Weed management strategies evaluated include cultivation, band herbicide application, broadcast herbicide application, and combinations of these tactics. The user may specify herbicide price, seed cost associated with herbicide resistant crop, application cost, cultivation cost, row spacing, and herbicide band width. Advisor then ranks the available strategies, including cultivation and various herbicide treatments and application methods in order of net return or in order of crop yield depending on the user's preference. Additional herbicide treatment selection criteria based on user input include soil properties, rotational crop, ground and surface water based restrictions, and crop and weed growth stage. Output includes an ordered ranking of weed management strategies based on net return or crop yield and a detailed economic and efficacy analysis of individual treatments. In addition an estimate of each treatments effect on the weed seedbank is provided.

WeedSOFT is useful in a teaching environment. Among the biological principles that can be illustrated using WeedSOFT are: differences in competitiveness of different crop species and weed species, the influence of weed and crop growth stage on crop-weed interference, and the influence of production practices including crop row spacing on crop competitiveness. The influence of environmental factors including soil properties and precipitation pattern on herbicide efficacy and risk to rotational crops can be systematically illustrated with WeedSOFT.

WEEDSOFT: EFFECT OF TOTAL COMPETITVE LOAD ON CORN YIELD LOSS PREDICTIONS. William G. Johnson, and Andrew A. Schmidt, Assistant Professor and Graduate Research Assistant University of Missouri, Columbia, MO 65211.

A computer decision aid called WeedSOFT is available for growers in Nebraska to assist in their weed management decisions. WeedSOFT has the potential of being another tool for growers and consultants in other states to use in their weed management decisions if it provides accurate efficacy and yield loss predictions. A regional project was initiated in 1999 to adopt WeedSOFT to other mid-western states. Two years of field trials were conducted in an attempt to evaluate the performance of the program. The objective of this presentation is to evaluate the yield loss prediction in corn in participating states. The herbicide treatments resulting in yield loss predictions of 20% and less were evaluated in Missouri, Illinois, Wisconsin, and Indiana corn trials to evaluate the accuracy of yield loss predictions at or near economic threshold levels. Conventional-till cultural practices were followed to produce corn in these areas. The experimental design of each site was a randomized complete block design with three or four replications. Initial weed counts and corn growth stage was recorded when weeds were 2.5- to 20.3-cm tall. Weed species and densities were entered into WeedSOFT to retrieve a list of allowable treatments ranked by predicted percent maximum yield. Treatments evaluated included a weed-free check, the recommendation that predicted the highest maximum yield, a treatment that will result in a 10% predicted yield reduction, the same treatment followed by cultivation 14 days after treatment, a treatment that will result in a 20% predicted yield reduction, and a cultivation treatment. Visual weed control ratings and weed counts for surviving weed species were collected 14 to 28 days after treatment. Harvest weed counts and yields were recorded in the fall. To evaluate the accuracy of the percent yield predictions, linear regression analysis was conducted on predicted versus actual yield loss values. A slope parameter estimate and coefficient of determination was calculated for each site-year, state, and four corn grain yield categories. A slope value of 1 would indicate a good correlation between predicted and actual yield loss values. The slope parameters ranged form 0.40 to 10.48 when the data were analyzed by site year. Sites that had treatments with consistent control between replications and low variability among weed densities at harvest time had a slope value between 0.6 to 0.81. When the data were analyzed by grain yield categories, sites that had low (<1419-kg/ha) or high (>2145-kg/ha) yields resulted in a slope value of 0.78 and 1.04, while the intermediate categories had a slope value of 2.31 to 3.57 respectively. Actual yield losses were generally greater than predicted yield losses in this version of the software. This would indicate that further modification to the efficacy database, competitive index assigned to the weeds, and yield loss function is warranted.

WEEDSOFT: EFFECT OF TOTAL COMPETITIEVE LOAD ON SOYBEAN YIELD LOSS PREDICTIONS. Christy L. Sprague, Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

WeedSOFT$_{SM}$ is a decision support system designed to assist growers, consultants, and educators in making weed management decisions. This interactive software is a bioeconomic model, which basis weed management decisions on the potential crop yield loss if no weed control measure is implemented. One factor used in the calculation of crop yield loss is total competitive load. The total competitive load takes in to account the sum of the individual weed species densities multiplied by their adjusted competitive indices. In 2000 and 2001, a series of field experiments were conducted in several North Central states that were interested in adapting WeedSOFT$_{SM}$. Individual WeedSOFT$_{SM}$ versions were used that were state specific for herbicide efficacy and weed competitiveness. One objective of this research was to determine how effective WeedSOFT$_{SM}$ was in predicting soybean yield based on total competitive load. For this experiment, soybeans were planted in 76-cm rows. Prior to postemergence herbicide applications, crop and weed sizes and densities were recorded for individual plots. This information was averaged over replications for individual treatments and entered into WeedSOFT$_{SM}$ to predict soybean yield for individual treatments. Common treatments included: weed-free and untreated plots, WeedSOFT$_{SM}$ generated treatments that provided maximum yield protection, and treatments that provided approximately 10% and 20% less than maximum yield. Predicted yield was correlated to actual yield after harvest. Yield correlations had a wide range, with a maximum correlation coefficient of r = 0.97. Weed density, type, and location had an affect on how well predicted yield correlated to actual yield.

WEEDSOFT: EFFECT OF SOYBEAN ROW SPACING ON BIOECONOMIC PREDICTIONS.
Chris M. Boerboom and Ryan D. Lins, Associate Professor and Graduate Research Assistant, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

Many research reports have documented greater weed control in narrow row soybeans as compared to wide row soybeans. This result is generally attributed to more rapid canopy closure with narrower row spacings. If soybean row spacing affects the competitive relationship between weeds and soybeans, this effect should be included in bioeconomic weed management models to improve their accuracy within different soybean production systems. WeedSOFT is a decision support software system for weed management that contains a bioeconomic model where yield loss is a function of the weeds' total competitive load. The competitive load is the product of a weed species' density by its competitive index. This product is summed for the different species present in the field to provide the total competitive load. Soybean row spacing is one of the site characteristics that users enter into WeedSOFT when defining a weed management scenario. Each row spacing has a value or modifier that is multiplied by the competitive index of any weed species that is entered in the program. For row spacings less than 30 inches, this reduces the competitive effect of the weeds. Current soybean row spacing modifiers are 0.8, 0.85, 0.9, 0.95, and 1 for 7.5-, 10-, 15-, 20- and 30-inch rows, respectively. Because a weed's competitive index is multiplied by the row spacing modifier, yield loss predictions have equal sensitivity to changes of either value. A 10% change in the row spacing modifier or competitive index results in a 10% change in the predicted yield loss and economic loss when the yield loss function is in the linear phase. Accurate estimates of the row spacing modifier are important at low competitive loads because it will influence whether or not an economic threshold is reached. At high weed competitive loads, the accuracy of the modifier will not significantly affect the yield loss prediction or the subsequent management decision. Accurate estimation of the row spacing modifier may be less crucial than the estimate of a weed's competitive index because the competitive indices may range from 0.25 to 10, whereas the row spacing modifier currently only ranges from 0.8 to 1. The effect of soybean row spacing on weed competitive abilities may also differ depending upon weed species, region of the Midwest, and soybean density, but the influence of these factors is probably minor relative to other estimates used in the model. The current soybean row spacing modifiers in WeedSOFT appear to be conservative estimates and should not be the cause for yield loss to be underestimated. Cooperators have the flexibility to increase the effect of the row spacing modifier as they adapt WeedSOFT for their states if local data support a change.

GROUNDWATER CONTAMINATION ISSUES IN WISCONSIN: INTRODUCTION AND OVERVIEW. David E. Stoltenberg, Associate Professor, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

Protection of groundwater resources has been an important issue, perhaps the dominant environmental issue, in Wisconsin for many years. The State of Wisconsin has been proactive and aggressive in efforts to characterize groundwater contamination issues, to devise and implement strategies for groundwater protection, to evaluate the effectiveness of these strategies, and ultimately to maintain a dynamic, responsive system for groundwater protection. The Wisconsin Groundwater Law was enacted in 1984 to provide a comprehensive legal framework for the protection of groundwater resources, including the establishment of groundwater standards. Although groundwater contamination emerged in the 1980's as a major issue related to agriculture in the Midwest and nationally, it was an issue based on limited data describing the extent of the problem. To address this problem, the State of Wisconsin was among the first states to comprehensively sample groundwater and well water for agrichemicals. Such efforts were critical for identifying specific contaminants, the extent of contamination (e.g. detection frequency and concentration), potential sources of contamination, and to devise protection strategies. A notable development in response to evidence of contamination was the Wisconsin Atrazine Rule, which was enacted in 1991. This rule restricted atrazine use rates on a statewide basis, established atrazine management areas, and atrazine prohibition areas. Implementation of the Atrazine Rule has been dynamic over time as atrazine use has been increasingly restricted such that prohibition areas currently total over 1.2 million acres. Just as important, the practices and restrictions imposed by the rule have been evaluated for their effectiveness in reducing groundwater contamination. Evidence to date suggests that the detection frequency of atrazine in groundwater has decreased over time, signifying an important environmental success story.

Herbicide use practices have changed dramatically over the last few years in the Midwest towards much more common use of herbicide chemistries that have low potential to contaminate groundwater resources (e.g. glyphosate) and less reliance on herbicide chemistries with greater potential to contaminate groundwater (e.g. triazines, chloroacetanilides). Nevertheless, groundwater protection has remained an important issue in Wisconsin. Regulatory agencies, research programs, and other groups in Wisconsin have focused on a wide range of efforts that include continued sampling and monitoring, continued evaluation of restrictions, development of criteria and procedures for repealing atrazine prohibition areas, better understanding of landscape-level effects on contaminant movement to groundwater, greater assessment of contamination associated with metabolites of chloroacetanilide herbicides, assessment of sulfonylurea herbicide movement in vulnerable soils and potential impact on aquatic ecosystems, and environmental risk assessment of new herbicide chemistries (e.g. isoxaflutole). The goal of this symposium is to provide detailed information about some of these critical efforts that have contributed to an aggressive approach to groundwater protection in Wisconsin.

ATRAZINE MANAGEMENT AND EFFECTS ON GROUNDWATER QUALITY. Jim VandenBrook, Water Quality Section Chief, Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP), Madison, WI 53718

To address groundwater quality concerns, Wisconsin farmers have been implementing restrictions on atrazine use, including rate reductions and prohibitions since 1991. Atrazine use rates in Wisconsin are limited to about one-half of the Federal label rate. Complete atrazine use prohibition occurs on over 1 million acres in 103 different areas statewide. Total atrazine use in Wisconsin has declined from 2,936,000 pounds of active ingredient (lbs a.i.) in 1990 to 1,424,000 lbs a.i. in 2000. DATCP designed two separate groundwater studies to determine the effect of atrazine management on groundwater quality. One study utilizes private drinking water wells and another samples shallow groundwater with monitoring wells

Between October 2000 and April 2001, 336 private drinking water wells were sampled as part of a statewide survey of agricultural chemicals in Wisconsin groundwater. Purposes of the survey were to establish a statewide picture of atrazine contamination and to compare the levels of atrazine in 2000 with levels founds in earlier surveys conducted in 1994 and 1996. The estimate of the proportion of Wisconsin wells that contained atrazine total chlorinated residues (atrazine and three chlorinated metabolites) was 11.6%. The estimate of the proportion of wells that exceeded the 3 ug/l enforcement standard for atrazine total chlorinated residues was 1.1%. The proportion of wells that contained a detectable level of parent atrazine showed a statistically significant decline between 1994 and 2000. However, the statewide proportion of wells with detects of atrazine total chlorinated residues did not show a statistically significant decline.

Beginning in 1998, DATCP initiated a 5 year study to determine the impact of current atrazine use rates on groundwater quality. Results from the study will be used to decide whether atrazine can be safely used again in current atrazine use prohibition areas. Monitoring wells have been sampled quarterly for atrazine and its chlorinated residues at 17 field sites. Prior to 1998, these sites had not received atrazine applications for a minimum of 5 years. Following atrazine applications sample results show rising levels of atrazine in groundwater with statistically significant upward trends at sites with coarse soil textures. Thirteen of 17 sites have at least one atrazine result that exceeds the enforcement standard of 3 ug/l. Sampling and data collection will continue through 2002.

LANDSCAPE AND MANAGEMENT VARIABILITY IMPACT ON PESTICIDE FATE. Birl Lowery, Francisco J. Arriaga and Harry W. Read, Professor, Research Associate and Assistant Scientist, Department of Soil Science, University of Wisconsin-Madison, 1525 Observatory Drive, Madison, WI 53706-1299

Data compiled by the Wisconsin Department of Agriculture Trade and Consumer Protection (WDATCP) show that pesticide leaching to groundwater varies considerably throughout the state of Wisconsin. Some of the obvious areas where pesticides have been found in groundwater include the sand plains in the Central Sands area of Wisconsin and in river valleys, such as the Lower Wisconsin River Valley. The combination of a shallow water table, limited pesticide sorption capacity caused by low organic matter content, and rapid drainage characteristics of these sandy soils makes them highly susceptible to leaching of agricultural chemicals. However, management practices such as a band application of pesticides to the center third of the crop row, in combination with ridge-tillage has been found to decrease pesticide and nitrate leaching from such landscapes. The WDATCP has also collected data from areas with fine textured soils where the soil organic matter content is relatively large, texture is not sandy, and water drainage is not excessive and found chemicals leaching to groundwater. Aside from instances of poor management, in these landscapes groundwater contamination likely originates from specific locations, which we have defined as critical sites, on the landscape. Factors leading to leaching of pesticides from critical sites include soil macropores that conduct water rapidly and closed basins with no surface drainage outlets. We have consistently found significantly greater leaching of atrazine, atrazine metabolites and metolachor in one of three closed basins compared to surrounding upland areas. Chemical leaching from depressions within these basins appears to vary with rainstorm duration and frequency and antecedent soil moisture conditions. For the other two basins the degree of leaching is less than that in the upland during some events and greater in the depressional areas within the basins during others. In addition to depressional areas, we have found that in areas where manure has been applied for several years to a silty soil there is greater leaching of atrazine. This management practice is generally viewed as good for soil physical properties, but we have found greater carbon leaching with manure applications. Atrazine adsorbed to the carbon may be carried deep into the soil and possibly leached to groundwater.

CHLOROACETANILIDE HERBICIDE METABOLITES IN WISCONSIN GROUNDWATER.
Jeffrey K. Postle, Groundwater Specialist, Wisconsin Department of Agriculture, Trade and Consumer Protection, PO Box 8911, Madison, WI, 53708-8911.

Alachlor, metolachlor and acetochlor belong to the chloroacetanilide class of herbicides. Each of these three parent compounds break down into unique ethane sulfonic acid (ESA) and oxanillic acid (OA) metabolites. The metabolites appear to have higher leaching potential than the parent compounds due to higher solubility and mobility in the environment. The main use of these herbicides in Wisconsin is for pre-emergence control of annual grass weeds in corn. In 2000, the total amount of active ingredient of these compounds applied in Wisconsin was approximately 3.8 million pounds. Except for alachlor ESA, laboratory methods for these metabolites did not exist until recently and there was no data on their occurrence in Wisconsin groundwater. Groundwater standards have not been established for these compounds and relatively little is known about their toxicology.

Starting in 1999, the Wisconsin Department of Agriculture, Trade and Consumer Protection has conducted two studies on the occurrence of chloroacetanilide herbicide metabolites in Wisconsin groundwater. The first study sampled 27 monitoring wells, 22 private drinking water wells, and 23 municipal wells. Wells were selected based on previous detections of pesticides or proximity to agricultural fields. Results showed detections of the ESA and OA metabolites of alachlor and metolachlor in over 80% of monitoring wells, over 90% of private drinking water wells, and over 50% of the municipal wells. The metabolites of acetochlor, which has only been used since 1994, showed a lower frequency of detection. Concentrations of the metabolites in groundwater ranged from near the level of detection (0.10 ug/l) to 42.1 ug/l.

The second survey involving chloroacetanilide metabolites was a statewide survey of pesticide and nitrate-nitrogen in private drinking water wells. The survey was completed in May 2001 and was a follow-up to similar surveys conducted by DATCP in 1994 and 1996. This survey included 336 wells which were selected using a stratified random sampling design. The main goal of this survey was to establish detection frequencies and concentrations for pesticides and nitrate-nitrogen in Wisconsin groundwater. Results of this study showed that alachlor ESA and metolachlor ESA were the most commonly detected compounds. The statewide estimates of the proportion of detections for alachlor ESA, metolachlor ESA, alachlor OA, and metolachlor OA were 27.8, 25.2, 3.7 and 6.4%, respectively. Estimates of the mean detect concentrations for these compounds ranged from near the level of detection to 1.84 ug/l. Parent alachlor, metolachlor and acetochlor were rarely detected.

MANUFACTURERS PERSPECTIVE ON GROUNDWATER PROTECTION STRATEGIES:
David Flakne, State Government Relations Manager, Syngenta Crop Protection, Madison, WI.

Syngenta Crop Protection considers environmental stewardship a top priority. By registering reduced risk pesticides, coordinating research on effective Best Management Practices, working with state agencies on policy proposals and with producers through education and outreach significant strides have been made to protect groundwater and surface water. The lessons learned and the successes realized will be shared from one manufacturers perspective.

FIELD-SCALE EVALUATION OF ATRAZINE AND *S*-METOLACHLOR LOSS IN SURFACE WATER RUNOFF. Ryan J. Rector, David L. Regehr, and Philip L. Barnes, Graduate Research Assistant and Professor, Department of Agronomy; Assistant Professor, Department of Biological and Agricultural Engineering, Kansas State University, Manhattan, KS 66506.

Atrazine and *S*-metolachlor have been widely used in corn and grain sorghum production to provide broadleaf and grass control. However, the chemical properties of atrazine and S-metolachlor make some loss from surface water runoff inevitable. It is important to minimize the amount of herbicide loss in surface water runoff because surface water is widely used for public drinking supplies in northeast Kansas. The objectives were to: 1) evaluate the effectiveness of pesticide and tillage Best Management Practices to improve water quality under field-scale conditions, and 2) build a data base and verify small-plot findings of a new BMP, fall-applied atrazine, for potential to reduce surface water contamination. A 30 acre field near Washington, KS was the site for experiments in 1999, 2000, and 2001. Timing, placement, and tillage variables were studied at this site to determine their influence on loss of atrazine and *S*-metolachlor. Individual watersheds, ranging from 1.0 to 3.5 acres and separated by contour terraces, were used for the collection of surface water runoff. Applications were broadcast as follows: (1) PPI-Tilled- 1.8 kg ha^{-1} atrazine and 1.4 kg ha^{-1} *S*-metolachlor one day prior to planting, (2) PRE-Tilled- 1.8 kg ha^{-1} atrazine and 1.4 kg ha^{-1} *S*-metolachlor one day after planting, (3) Fall+PRE-No Till- 1.7 kg ha^{-1} atrazine and 1.1 kg ha^{-1} *S*-metolachlor split applied, (4) EPP+PRE-No Till- 1.3 kg ha^{-1} atrazine and 0.9 kg ha^{-1} *S*-metolachlor split applied, (5) PRE-No Till- 1.8 kg ha^{-1} atrazine and 1.4 kg ha^{-1} *S*-metolachlor one day after planting. Across all years, timing, placement, and tillage variables, atrazine and *S*-metolachlor loss was similar at 0.36 and 0.49% of applied. Preplant soil incorporation reduced atrazine and *S*-metolachlor loss in surface water runoff by 91 and 74%, respectively, compared to soil surface applications on a tilled soil. An EPP + PRE split application on a no-till soil reduced losses of atrazine and *S*-metolachlor in surface water runoff by 72 and 51% when compared to at planting time applications on a tilled soil. Comparatively, a Fall+PRE split application on a no-till soil reduced losses of atrazine and *S*-metolachlor lost in surface water runoff by 34 and 14% when compared to at planting time applications on a tilled soil. These findings suggest that best management practices such as soil incorporation, split applications, and no-till can significantly reduce the amount of atrazine and *S*-metolachlor lost in runoff.

OVERCOMING ANTAGONISM OF POST SULFONYLUREA HERBICIDES ON YELLOW FOXTAIL. Richard K. Zollinger and Jerry L Ries, Associate Professor and Research Specialist, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Dicamba antagonism of nicosulfuron on yellow foxtail is a common in North Dakota. Studies with identical treatments were conducted at two field locations to evaluate yellow foxtail (1 to 3 and 2 to 6 inch tall, respectively) control from nicosulfuron, nicosulfuron&rimsulfuron (Steadfast), and foramsulfuron applied at labeled and reduced rates with tank-mixtures of atrazine with dicamba or dicamba applied sequentially 7 days later. Atrazine was applied 0.38 lb/A in respective treatments. Treatments were applied with basic blend, petroleum oil plus liquid nitrogen, and MSO adjuvants. Most treatments containing foramsulfuron gave poor and inadequate yellow foxtail control. Most treatments containing nicosulfuron or Steadfast plus atrazine applied in combination with or previous to dicamba on 1 to 3 inch tall yellow foxtail gave 73% to 88% control and applied to 3 to 6 inch tall yellow foxtail gave 60 to 77% control. The only treatments that gave greater than 90% yellow foxtail control were those containing full rates of nicosulfuron and Steadfast, applied with an MSO adjuvant, and applied without dicamba to 1 to 3 inch tall foxtail. In general, treatments containing Steadfast gave greater foxtail control than those containing nicosulfuron. Greater yellow foxtail control occurred when applications were made with MSO adjuvant as opposed to other adjuvant types used, without dicamba in the mixture, and applying treatments to 1 to 3 inch rather than 2 to 6 inch yellow foxtail. Yellow foxtail control was greatly reduced when reduced rates of POST grass herbicides were used and when treatments were applied to 2 to 6 inch tall as compared to 1 to 3 inch tall yellow foxtail.

Studies were also conducted at the same two field locations to evaluate yellow foxtail from nicosulfuron, nicosulfuron& rimsulfuron (Steadfast), and foramsulfuron applied at full labeled rates with tank-mixtures of atrazine plus carfentrazone, flumetsulam&clopyralid (Hornet), primisulfuron&dicamba (NorthStar), and mesotrione plus atrazine. Atrazine was applied 0.38 lb/A in respective treatments. Yellow foxtail control was 47 to 68% from nicosulfuron or Steadfast combined with any broadleaf herbicide mixture except mesotrione. POST grass herbicides applied with mesotrione, atrazine and MSO adjuvant gave near complete control. Results were much less from formasulfuron applied with the same broadleaf herbicides but in combination with mesotrione and atrazine only gave 78% control. Mesotrione enhanced yellow foxtail control from nicosulfuron, Steadfast, and foramsulfuron.

USING SAFENERS IN HERBICIDES TO REDUCE CORN INJURY FROM RPA21772 ACROSS NEBRASKA IN 2001. Gail A. Wicks, Robert G. Wilson, Stevan Z. Knezevic, Robert N. Klein, Alex R. Martin, and Fred W. Roeth. University of Nebraska, North Platte, Scottsbluff, Concord, North Platte, Lincoln, and Clay Center, NE, respectively.

Soil types where chances of response to isoxaflutole would be greatest were at the North Platte ridge-till site and Scottsbluff because pH's were 7.9 and 8.1, respectively. These two sites plus the North Platte ecofallow site had organic matter content of 2% or less. Field studies using CGA-154281 (metolachlor, Dual II Magnum), dichlormid (acetochlor, Surpass), MON 4460 (acetochlor, Harness), and R-29148 (acetochlor + EPTC, DoublePlay) safeners in combination with their appropriate preemergence corn herbicide were applied at six locations across Nebraska. MON 13900 (Battalion) was also used at Clay Center. 'Pioneer 33-G' a sensitive corn hybrid to RPA 201772 (proposed common name isoxaflutole) was planted 1- and 2-inches deep. Four herbicides containing the above safeners were applied at suggested rates for that soil plus isoxaflutole at 1X and 2X rates for soils involved. These rates were based on the rates suggested in 1999.

Success with the safeners varied with location and number of days after planting that maximum injury occurred. Timing of rainfall, sprinkler irrigation, and amount were important in corn response to isoxaflutole. Corn at the Lincoln and North Platte ecofallow sites showed little effect from the isoxaflutole because rainfall came too late. The Clay Center and Scottsbluff sites were sprinkle irrigated after planting and at Concord timely rainfall occurred. In general, safeners protection varied with location, herbicide rate, and depth of planting. The of the four sites that had significant isoxaflutole response rainfall or irrigation occurred soon after planting. At Clay Center, R-29148 in DoublePlay at 2 pt/A protected corn from isoxaflutole at 1X rate, but not at 2X. DoublePlay at 4 pt/A protected corn at both rates from early injury. Isoxaflutole alone did not stunt corn. Corn grain yields were not different among treatments. At Scottsbluff, shallow planted corn was injured more than when planted at the 2-inch depth. All treatments caused more injury than the handweeded check. Isoxaflutole mixed with Dual II Magnum or Harness caused more corn injury than the isoxaflutole 1X rate, but only DoublePlay reduced injury at the 2X rate. At Concord, safeners had no affect at low isoxaflutole rate, but DoublePlay, Harness, and Surpass reduced corn injury at the 2-inch depth at the high isoxaflutole rate. The North Platte ridge-till site, showed no injury until 3 days after anhydrous ammonia was applied 50 DAP. Plots treated with isoxaflutole + Dual II Magnum at the 1X rate received a 25% visual injury rating and the 2X rate was 43% injury 5 days after anhydrous ammonia was applied. Rainfall was not a factor as rain did not occur for 2 weeks before injury occurred. Grain yield was reduced 13%. In summary, the best defense against isoxaflutole injury is using rate suggested for the soil. The safener that appeared to reduce early isoxaflutole response most consistently was R-29148 and the one that provided the least was CGA-154281.

These safeners should be researched using the safeners independently of the herbicide that they are presently used with. Some times the addition of the herbicide containing the safener caused more injury than isoxaflutole alone. Most corn recovered from the early response in most situations and did not affect grain yield.

CROP TOLERANCE AND EFFICACY OF FLUMETSULAM + CLOPYRALID TANK MIXED WITH REDUCED RATES OF DICAMBA + DIFLUFENZOPYR IN FIELD CORN. Scott C. Ditmarsen, Jon M. Babcock, Neivaldo T. Caceres, Steven P. Nolting, Sarah Taylor-Lovell, Larry G. Thompson, and Terry R. Wright, Development Biologists, Dow AgroSciences LLC, Indianapolis, IN 46268.

Field experiments were conducted at six locations to evaluate the crop tolerance and broadleaf weed efficacy of tank mixtures of flumetsulam + clopyralid (Hornet WDG, 144 g/ha) with reduced rates of dicamba + diflufenzopyr (Distinct, 49, 78, 98, and 147 g/ha) applied early postemergence in field corn. Treatments were compared to tank mixes of flumetsulam + clopyralid (144 g/ha) with reduced rates of dicamba (Banvel, 140, 280, and 560 g/ha) and the 1x rates of dicamba + diflufenzopyr (294 g/ha) and primisulfuron + dicamba (Northstar, 166 g/ha) applied alone. Above ground crop injury one week after application averaged less than 10 percent for flumetsulam + clopyralid tank mixed with reduced rates of dicamba + diflufenzopyr and was less than that observed from tank mixtures of flumetsulam + clopyralid with reduced rates of dicamba and the 1x rates of dicamba + diflufenzopyr and primisulfuron + dicamba applied alone. Field corn brace root injury data collected 8 to 11 weeks after application showed similar relative treatment differences. The tank mixture of flumetsulam + clopyralid with 49 g/ha dicamba + diflufenzopyr provided over 95 percent control of common cocklebur, common lambsquarters, common sunflower, eastern black nightshade, redroot pigweed, and velvetleaf eight weeks after application. Ninety-eight and 147 g/ha of dicamba + diflufenzopyr were required in the tank mix to control common waterhemp and morningglory species, respectively. Control of all weeds with tank mixtures of flumetsulam + clopyralid with reduced rates of dicamba + diflufenzopyr was equivalent to or better than that provided by the other treatments. Results of this research indicate that flumetsulam + clopyralid tank mixtures with reduced rates of dicamba + diflufenzopyr provide acceptable crop tolerance and effective control of key broadleaf weeds, as compared to tank mixtures of flumetsulam + clopyralid with reduced rates of dicamba or other dicamba-based products applied alone.

WEED CONTROL WITH COMBINATIONS OF CLOPYRALID + FLUMETSULAM WITH NICOSULFURON OR RIMSULFURON + NICOSULFURON. Sarah Taylor–Lovell*, Terry R. Wright, Larry Thompson, and Neivaldo Caceres, Field Research Biologists, Dow AgroSciences, Indianapolis, IN, 46268.

Eight trials were conducted across the Midwest US to determine crop tolerance and weed control resulting from clopyralid + flumetsulam (Hornet WDG[1]) with or without atrazine when used in combination with 0.25, 0.50, 0.75, and 1 X rates of nicosulfuron (Accent) or rimsulfuron + nicosulfuron (Steadfast). Crop tolerance was excellent, with all treatments averaging less than 10% visual injury 1 to 4 weeks after application (WAA). In ratings taken 4 WAA, the clopyralid + flumetsulam premix at 144 g ae/ha controlled (>90%) velvetleaf, common cocklebur, common sunflower, Pennsylvania smartweed, common lambsquarters, and shepherdspurse, regardless of the nicosulfuron or nicosulfuron + rimsulfuron rate. Tank-mixing atrazine at 840 g ai/ha with clopyralid + flumetsulam was required to provide at least 90% control of common waterhemp, tall waterhemp, prickly sida, and ivyleaf morningglory. In combination with clopyralid + flumetsulam, nicosulfuron at 17.5 g ai/ha (0.5 X) controlled woolly cupgrass, seedling johnsongrass, and shattercane, while at least 26.25 g ai/ha (0.75 X) nicosulfuron was required to control foxtail sp. The rimsulfuron + nicosulfuron premix tank-mixed with clopyralid + flumetsulam controlled shattercane with 9.85 g ai/ha (0.25 X), seedling johnsongrass, woolly cupgrass, and green foxtail with 19.7 g ai/ha (0.5 X), and giant foxtail and robust purple foxtail with 29.5 g ai/ha (0.75 X). Data from these trials indicate reduced rates of nicosulfuron or nicosulfuron + rimsulfuron tank-mixed with clopyralid + flumetsulam can provide effective annual grass weed control while maintaining broad-spectrum broadleaf weed control.

[1] Trademark of Dow AgroSciences, LLC.

EVALUATION OF FORAMSULFURON (AE F130360) HERBICIDE PERFORMANCE IN PRE/POST SYSTEMS ACROSS MIDWESTERN UNIVERISTY AND EUP TRIALS. Jayla R. Allen*, Chad Effertz, and Marc Hoobler. *Technical Development Representative, Aventis CropScience, Research Triangle Park, NC 27709.

Foramsulfuron (AE F130360; 1-(4,6-dimethoxypyrimidin-2-yl)-3-(2-dimethylcarbamoyl-5-formamidophenylsulfonyl)urea) is a novel sulfonylurea herbicide for post-emergence use in corn. Foramsulfuron is effective against major grass weed species, as well as some broad-leaved weeds. It is applied with the new Aventis CropScience safener, isoxadifen-ethyl (AE F122006; ethyl 5,5-diphenyl-2-isoxazoline-3-carboxylate). AE F130360 35 WG (35% foramsulfuron) In a 1:1 ratio with Isoxadifen-ethyl and has a recommended use rate of 0.033 lb ai/A. AE F130360 has the flexibility to be utilized in a wide variety of tankmixes and is applied with methylated seed oil and UAN or AMS. The trade name for AE F130360 35 WG is Option™.

University researchers evaluated the efficacy of foramsulfuron in 2000 and 2001 in pre/post systems. In 2000, 15 university trial evaluations of isoxaflutole + atrazine fb foramsulfuron + MSO + N provided excellent control of annual grasses and broadleaf weeds.

In 2001, foramsulfuron was more closely evaluated in potential commercially applicable pre/post weed control programs at Midwest universities. Treatments included a reduced rate of isoxaflutole alone and followed by foramsulfuron + MSO + N, a reduced rate of isoxaflutole + atrazine alone and followed by foramsulfuron + MSO + N, reduced rate of flufenacet followed by foramsulfuron and a comparative standard of atrazine + dimethenamid followed by atrazine + nicosulfuron + rimsulfuron. Excellent crop safety was exhibited in all treatments. Foramsulfuron following reduced rate isoxaflutole, reduced rate isoxaflutole + atrazine, or reduced rate of flufenacet preemergence provided excellent control of all annual grass, velvetleaf, common lambsquarters, common ragweed, giant ragweed, amaranthus species, common cocklebur and common sunflower in midwestern university evaluations. All pre/post treatments containing foramsulfuron provided similar or better than the competitive standard in paired comparisons.

Experimental use permit (EUP) trials with foramsulfuron were conducted throughout the Midwest in 80 locations in 2001. Excellent crop safety was exhibited. In pre/post evaluations, isoxaflutole followed by foramsulfuron + MSO + N provided excellent control of annual grass and broadleaf weeds.

FORAMSULFURON (AE F130360) HERBICIDE PERFORMANCE IN POSTEMERGENT WEED CONTROL PROGRAMS. Marc A. Hoobler*, Jayla R. Allen, and Chad J. Effertz, Aventis CropScience, ResearchTriangle Park, NC.

Foramsulfuron (AE F130360; 1-(4,6-dimethoxypyrimidin-2-yl)-3-(2-dimethylcarbamoyl-5-formamidophenylsulfonyl)urea) is a novel sulfonylurea herbicide for post-emergence use in corn. Foramsulfuron is effective against major grass weed species, as well as some broad-leaved weeds. It is applied with the safener, isoxadifen-ethyl (AE F122006; ethyl 5,5-diphenyl-2-isoxazoline-3-carboxylate). Foramsulfuron and isoxadifen-ethyl are always applied at a 1:1 ratio. Several research trials were conducted at universities and by Aventis CropScience across the midwest in 2000 and 2001 to evaluate the performance of foramsulfuron on grass and broadleaf weeds.

In university trials, foramsulfuron provided superior broadleaf weed control and equivalent grass control when compared to nicosulfuron. Control in eigthy-six paired broadleaf comparisons was 80 and 65 percent respectively, while control in forty-one paired grass comparisons was 89 and 89 percent respectively. Significant broadleaf advantages were realized on velevetleaf, common ragweed, giant ragweed, common lambsquarters, prickly sida and common cocklebur. Foramsulfuron provided similar grass control and inferior broadleaf control when compared to nicosulfuron+rimsulfuron+atrazine. Control in seventy-eight paired broadleaf comparisons was 79 and 90 percent respectively, while control in thirty-seven paired grass comparisons was 88 and 90 percent respectively. Nicosulfuron+rimsulfuron+atrazine broadleaf advantages were realized on als-resistant waterhemp and kochia. The additon of atrazine to foramsulfuron provided 96 percent control of all broadleaf weeds in comparison to 91 percent for nicosulfuron+rimsulfuron+atrazine. Foramsulfuron+atrazine provided better control of velvetleaf and ragweed species than did nicosulfuron+rimsulfuron+atrazine.

In trials conducted by Aventis Cropscience, similar results were found. Foramsulfuron+atrazine provided similar grass and broadleaf weed control when compared to nicosulfuron+rimsulfuron+ atrazine. Control in fifty-three paired broadleaf comparisons was 91 and 93 percent respectively, while control in 22 paired grass comparisons was 93 and 95 percent respectively.

In university trials, maximum corn injury occurred within seven days after treatment and was highest with nicosulfuron+rimsulfuron+atrazine with an average of 4.8 percent injury in thirty trials. Foramsulfuron injury averaged 3.2 percent in sixty-three trials and nicosulfuron injury averaged 1.2 percent in 31 trials.

In Aventis Cropscience trials, maximum corn injury also occurred within seven days after treatment. Foramsulfuron+atrazine and nicosulfuron+rimsulfuron+atrazine injury averaged less than 1 percent when applied at an early postemergent timing.

THE EFFECT OF ADJUVANT ON FORAMSULFURON AND ISOXADIFEN-ETHYL PERFORMANCE. Chad Effertz*, Ken Pallett, Richard Rees. *Product Development Corn and Soybean Herbicides, Aventis CropScience, Research Triangle Park, NC

Foramsulfuron (AE F130360; 1-(4,6-dimethoxypyrimidin-2-yl)-3-(2-dimethylcarbamoyl-5-formamidophenylsulfonyl)urea) is a novel sulfonylurea herbicide for post-emergence use in corn. Foramsulfuron is effective against major grass weed species, as well as some key broad-leaved weeds. It is applied with the safener, isoxadifen-ethyl (AE F122006; ethyl 5,5-diphenyl-2-isoxazoline-3-carboxylate). Foramsulfuron and isoxadifen-ethyl are always applied at a 1:1 ratio.

Studies from 1996 through 2001 have shown that foramsulfuron and isoxadifen-ethyl performance is influenced by adjuvant type. Penetrant adjuvant comparisons consisted of esterified seed oils, crop oil concentrates and non-ionic surfactants. Nitrogen fertilizer was added to all penetrant adjuvants in the form of liquid urea-ammonium nitrate (UAN) or dry ammonium sulfate (AMS). Tests were also conducted comparing UAN or AMS in combination with esterified seed oils. Foramsulfuron's solubility in water is improved as the pH of the spray solution increases. Buffers modifying the pH of the spray solution were tested in comparison to UAN.

Foramsulfuron plus an esterified seed oil provided greater efficacy in comparison to crop oil concentrate or non-ionic surfactant. Weed species that responded to the use of an esterfied seed oil included giant foxtail and common lambsquarters. Crop oil concentrate provided better grass efficacy and similar broadleaf efficacy to non-ionic surfactants. The addition of nitrogen fertilizer to an esterified seed oil enhanced grass and broadleaf weed control. Foramsulfuron responded similarly to UAN and AMS in most environments. Velvetleaf showed the greatest efficacy improvement with the addition of nitrogen fertilizer. Under arid conditions UAN generally outperformed AMS. Increasing the pH of the spray solution did not influence foramsulfuron weed control, except when conditions were extremely arid at application. Alkaline pH buffers increased the solubility of foramsulfuron and in low humidity environments the buffers tended to improve weed control. However, alkaline pH buffers plus an esterfied seed oil still provided less control than UAN plus esterfied seed oil.

Foramsulfuron showed similar corn phytoxicity across all adjuvant systems. Isoxadifen-ethyl reduced foramsulfuron phytotoxicity in corn by increasing the rate of foramsulfuron degradation. Isoxadifen-ethyl uptake was optimized by the addition of an esterified seed oil adjuvant. In conclusion, the recommended adjuvant for optimum foramsulfuron and isoxadifen-ethyl performance will be an esterified seed oil plus nitrogen fertilizer.

CORN TOLERANCE AND WEED CONTROL WITH MESOTRIONE AS AFFECTED BY APPLICATION TIMING AND ADDITIVES. James J. Kells and Andrew J. Chomas, Professor and Research Technician, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

A 2001 field trial was conducted to determine the effect of mesotrione application timing on field corn tolerance and weed control. Application timings included preemergence, two visible corn leaves, and four visible corn leaves. In addition, tank mixtures with s-metolachlor, microencapsulated acetochlor, and pendimethalin were compared to mesotrione applied alone. Mesotrione was also applied to 4-leaf corn with crop oil concentrate and liquid nitrogen fertilizer. None of the treatments tested caused more than 15 percent visible corn injury. Injury symptoms were not evident 22 days after application. At the 2-leaf stage, mesotrione tank mixtures with s-metolachlor or pendimethalin resulted in significantly greater corn injury than mesotrione alone. Mesotrione caused more corn injury to 4-leaf corn when applied at 0.2 kg ai/ha than at 0.1 kg ai/ha. Control of common lambsquarters and velvetleaf was complete with each application timing and tank mixture. Mesotrione applied preemergence provided 70 percent common ragweed control. Preemergence tank mixtures significantly improved common ragweed control. Common ragweed control was greater when mesotrione was applied after corn emergence. Giant foxtail control was inadequate with mesotrione alone, regardless of application timing. Each tank mixture significantly improved giant foxtail control compared to mesotrione alone. Delaying application until the 4-leaf stage significantly reduced giant foxtail control with mesotrione tank mixtures.

EARLY POSTEMERGENCE APPLICATION OF MESOTRIONE AND s-METOLACHLOR WITH SELECTED ADJUVANT SYSTEMS. Michael J. Urwiler, Research and Development Scientist, Syngenta Crop Protection, Greensboro, NC 27419.

Mesotrione (2-[4-methylsulfonyl-2-nitrobenzoyl]-1,3-cyclohexanedione) at 105 or 210 g/ha was tank-mixed with 1780 g/ha s-metolachlor plus selected adjuvants. These tank-mix combinations were tested postemergence for weed control activity and selectivity in field corn. The adjuvants tested included: no adjuvant, 1% v/v crop oil concentrate (COC), 1% v/v COC plus 2.5% v/v urea ammonium nitrate (UAN), 0.25% v/v nonionic surfactant (NIS) and 0.25% v/v NIS plus 2.5% v/v UAN. The results indicated that the tank-mix combination of mesotrione at 105 or 210 g/ha plus 1780 g/ha s-metolachlor plus no adjuvant was very effective at controlling the major broadleaf weeds in field corn when applied early postemegence. This tank-mix was very safe to most corn hybrids and only caused minor phytotoxicity to a hybrid known to be sensitive to mesotrione. The other adjuvant systems were equally effective with respect to weed control but crop response varied. The adjuvant systems of 0.25% v/v NIS or 0.25% v/v NIS plus 2.5% v/v UAN were safe to corn when used with mesotrione and s-metolachlor. The most injurious combination of adjuvants when mix with mesotrione and s-metolachlor was 1% v/v COC plus 2.5 % v/v UAN. The second most injurious adjuvant was 1% v/v COC. Generally, these two adjuvant systems should be avoided if postemergence applications of mesotrione and s-metolachlor are planned.

NEW MESOTRIONE PREMIXES FOR BROADSPECTRUM WEED CONTROL IN CORN. Brett R. Miller, Research and Development Scientist, Syngenta Crop Protection, Greensboro, NC 27419.

Mesotrione (2-[4-methylsulfonyl-2-nitrobenzoyl]-1,3-cyclohexanedione) pre-packaged mixes with s-metolachlor and s-metolachlor plus atrazine are currently under development by Syngenta Crop Protection. These new mixtures are being developed for preplant, preemergence and early postemergence use in corn. Mesotrione provides excellent control of most important broadleaf weeds in corn including velvetleaf, pigweed species, waterhemp species, common lambsquarters, common ragweed, giant ragweed, jimsonweed, nightshade species, common sunflower and Pennsylvania smartweed. The addition of s-metolachlor or s-metolachlor plus atrazine to mesotrione in pre-packaged mixes results in the control of a broad spectrum of annual grass and broadleaf weeds. Corn shows excellent tolerance to mesotrione plus s-metolachlor or mesotrione plus s-metolachlor plus atrazine pre-packaged mixes.

THE IMPACT OF A SINGLE RESIDUE INCORPORATION ON THE SEED SOIL BANK OF *PALMER AMARANTH* UNDER SIX CROP MANAGEMENT HISTORIES. Randall S. Currie, Associate Professor, Southwest Research and Extension Center, Kansas State University, Garden City, KS 67846

Most weed control studies do not account for the long-term effect of weed seeds when studying a particular management system. Following the completion of a 3-year study of 3 levels of atrazine (0, 0.8 and 1.8 kg/ha) with and without a cover crop for production of irrigated corn (described in Proc. of WSSA 41:132.). A second study was initiated in October 2000 in which half of each of these six systems was tilled with two passes of a double gang disk. This tillage created a study to measure the impact of tillage on the seed soil bank created by these 12 cropping systems. In the spring of 2001 the fallow phase of a corn-fallow-corn rotation was commenced, with bi-weekly weed counts followed by a 1.1 kg/ha application of glyphosate.

A history of atrazine use reduced *Palmer amaranth* seedling emergence by 2 to 33 fold early in the season across all management systems. Due to variability, these differences were not always statistically significant. Tilled plots with a previous history of atrazine use showed a dramatic reduction in *Palmer amaranth* seedling emergence compared to untilled plots without previous atrazine use.

The effect of previous cropping system was diminished by June 6. At that point, all systems were similar, with the exception of the cover crop with no fall tillage system. With a previous history of atrazine use, this management system produced 77.6 fewer seedlings per m^2. By June 11 all systems produced similar numbers of emerged seedlings. *Palmer amaranth* seedling emergence declined dramatically and variability increased from June 27 to July 30. Cumulative germination for these rating dates was 3 to 4 fold less than any previous single rating date. Cumulative emergence for the season across all levels of management did not differ and ranged from 232 to 327 *Palmer amaranth* seedlings per m2. Although previous management history affected the timing of *Palmer amaranth* emergence, total seasonal depletion of its seed soil bank was not affected.

SHOULD GIANT CHICKWEED (MYOSOTAN AQUATICUM) STILL BE CONSIDERED A WISCONSIN WILDFLOWER? Michael P. Crotser and Scott Bollman, Assistant Professor and Undergraduate Research Assistant, Department of Plant and Earth Science, University of Wisconsin at River Falls, River Falls, WI, 54022.

Giant chickweed (*Myosotan aquaticum*), a native species of Europe, was thought to predominately inhabit moist, natural areas of Wisconsin. In recent years its presence has been confirmed in perennial crops in Pierce, Green, St. Croix, Lafayette, Grant, Columbia, Sauk, and Shawano counties. Due to morphological similarities between the chickweed species, presence and distribution of giant chickweed has likely been underestimated in Wisconsin. The objective of this study was to develop classification methods for taxonomic separation from other chickweeds in agronomic settings and to provide preliminary data on chemical control in alfalfa and pastures. Giant chickweed is a perennial and a member of the Caryophyllaceae family. Giant chickweed's growth is more robust when compared to other chickweed's in Wisconsin. The leaves, stem tissue, and flowers of giant chickweed are larger with a typical plant height of 60 cm, indicating potentially greater competitive ability in crops such as alfalfa. Other characteristics include rough, angular sticky stems that root at the nodes, sessile cordate leaves, and flowers with five deeply notched white petals. In a study metsulfuron, dicamba, 2,4-D, 2,4-D + dicamba, imazethapyr and metribuzin were applied at a full label rate to active growing giant chickweed in pasture with a CO_2 backpack sprayer. Spray volume was 25 GPA and plots were sprayed on July 26, 2001. At 21 DAT metribuzin provided 93% control, whereas metsulfuron and dicamba provided 87% and 80% control, respectively.

WOOLLY CUPGRASS EMERGENCE AND CONTROL IN RESPONSE TO TIME OF TILLAGE.
James F. Lux, Damian D. Franzenburg, and Micheal D. K. Owen, Ag Research Specialists, and Professor, Agronomy Department, Iowa State University, Ames, IA 50011.

A field experiment was established to assess the impact of tillage timing on woolly cupgrass control, germination and emergence. A site was selected in 1999, 2000 and 2001 to establish a split-plot experiment with six replications. Whole-plot treatment was tillage timing. Split-plot treatments were field cultivation and no-tillage. Glyphosate was applied to the split-plots to control emerged woolly cupgrass at initiation of each treatment timing. No crop was planted. Treatment timing was weekly beginning mid-April and occurred once per treatment. Data collection included initial enumeration of emerged woolly cupgrass immediately prior to each treatment timing, and final enumeration at five or six weeks.

No significant differences in final woolly cupgrass number, averaged across treatment timing, were found between field cultivation and no-tillage in all three years of the study. Field cultivation did not significantly impact the germination and subsequent emergence of woolly cupgrass compared to no-tillage.

Field cultivation and no-tillage treatment results were averaged for each of the three years to examine the overall affect of treatment timing. Woolly cupgrass emergence in 1999 initially occurred on April 14. The first treatment timing was April 21. Initial woolly cupgrass populations were significantly higher on the May 18 and 24 timings when compared to April 21 and 29. The highest number occurred on May 4 and was significantly higher than all other dates. Five weeks following the April 21 timing, a higher number of plants were noted than at treatment initiation, while all other timings had less. Further, April 29, May 4, 18, and 24 timings resulted in significantly fewer numbers five weeks after treatment, compared to April 21.

During 2000, the first treatment timing was April 14, coinciding with the initial date of woolly cupgrass emergence. On May 12 and 25 timings, initial woolly cupgrass populations were significantly higher compared to April 14 and 21. Two other timings on April 27 and May 4 were significantly different than April 14, but not the others. Woolly cupgrass numbers six weeks after the May 25 timing were significantly less when compared with the April 21 and 27 timing. It was not significantly different, however, than the April 14, May 4, and 12 timing.

Initial woolly cupgrass emergence in 2001 was observed on April 16. Initial woolly cupgrass populations on April 26, May 8, 15, 25, and June 4 timings were significantly higher on these dates than on April 19, the first timing. April 26, May 8, and 15 timings also had significantly higher numbers at treatment initiation than May 25 and June 4. Six weeks following the April 19 timing, a higher number of woolly cupgrass plants were noted than at treatment initiation. All other timings had fewer. April 26, May 8, 15, 25, and June 4 timings resulted in significantly fewer numbers six weeks after treatment, compared to April 19.

EFFECT OF TILLAGE ON WOOLLY CUPGRASS POPULATION. Damian D. Franzenburg, James F. Lux, and Micheal D. K. Owen, Ag Specialists and Professor, Agronomy Department, Iowa State University, Ames, IA 50011.

A four year field experiment was initiated in fall, 1998 to determine the effect of tillage management strategy and herbicide treatment on woolly cugrass population and seedbank dynamics. The split-plot experiment, containing tillage as the whole plot and herbicide treatment as the split-plot, was established near Ogden, IA. The crop rotation was corn and soybean. Treatments were replicated four times.

Whole plot tillage treatments following corn included fall chisel plow, fall disk and no-tillage. Following soybean, these treatments were fall chisel, spring field cultivation and no-tillage, respectively. Spring seed bed preparation included field cultivation on the fall chisel and fall disk plots. Split-plot treatments included a weed-free treatment that received a postemergence herbicide application supplemented with handweeding. The second treatment received an early single postemergence herbicide application with expectations of escaped woolly cupgrass plants returning seeds to the soil seed bank. Herbicide treatments and application rates varied to suite the existing weed spectrums.

Woolly cupgrass seed distributions in the seed bank were determined by soil sampling prior to tillage each fall. Soil samples were subdivided into 0-5, 5-10 and 10-15 cm cores. Woolly cupgrass plants were enumerated prior to implementation of herbicide treatments. Additionally, 10 woolly cupgrass plants per plot were excavated and measured to determine depth from which germination occurred.

Seed bank numbers from 1998, prior to experiment initiation, indicated no differences between treatments. The vertical seed distribution demonstrated that the 0-5 cm depth had significantly higher numbers than the 5-10 and 10-15 cm depths. In 1999, soil sampling revealed that spring disk, averaged over all treatments, had significantly fewer seed numbers than chisel plow and no-tillage treatments. Chisel plow and no-tillage treatments were not significantly different. Woolly cupgrass seed numbers were halved when the single herbicide application was compared to the weed free control. Vertical seed distribution, averaged over all treatments, was highest at 0-5 cm depth. The 5-10 cm depth had significantly higher seed numbers than the 10-15 cm depth. Within the 0-5 cm depth, seed numbers were very high in the no-tillage treatment. Seed numbers in the spring disk treatment tripled with each decrease in soil depth from 10-15 to 5-10 to 0-5 cm. The chisel plow treatment, however, had the highest seed numbers in the 5-10 cm depth, followed by 0-5 and then 10-15 cm.

Plant counts were conducted for 1999 and 2000. As expected, the 2000 weed free treatment demonstrated lower emergence. Tillage treatments did not demonstrate the same trend for emergence and seed numbers; no-tillage plots had the highest 1999 seed numbers but lowest 2000 emergence. Chisel plow and spring disk treatments were similar in 2000 emergence, even though 1999 seedbank counts demonstrated lower seed numbers for the spring disk treatment.

Germination depth was also measured in 1999 and 2000. Chisel plow and spring disk treatments demonstrated similar mean germination depths. The no-tillage germination depths were shallower for both years.

WEED SHIFTS IN NO-TILL GLYPHOSATE-TOLERANT CROPS IN SEMIARID AREAS OF THE GREAT PLAINS. Gail A. Wicks, Professor, University of Nebraska, West Central Research and Extension Center, North Platte, NE 69101; Phillip W. Stahlman, Professor, Kansas State University, Agricultural Research Center, Hays, KS 67601-9228; Jeffrey M. Tichota, Monsanto, Littleton, CO 80122; and Troy M. Price, Assistant Scientist, Kansas State University, Northwest Research-Extension Center, Colby, KS 67701.

Studies were conducted at North Platte, NE and Colby, KS to determine weed shifts after 4 years of glyphosate applications in a continuous corn and corn-soybean rotation using glyphosate-tolerant crops. Each phase of the rotation occurred each year and glyphosate was applied to kill all weeds before no-till planting corn or soybean. Four weed control treatments were compared. Glyphosate at 0.38 or 0.75 lb ae/A was applied twice POST to separate plots in each rotation each year. The check was a standard non-glyphosate herbicide treatment for corn and soybean. The fourth treatment consisted of using the low rate of glyphosate twice in one year and the standard herbicide treatment in the next year. Weeds were most difficult to control in the standard herbicide treatment, so each year we raised rates or substituted herbicides.

Changes in weed species occurred at both locations during the 4 years with new species occurring each year. At North Platte, 50+ species were identified in 2000 and 2001. At harvest time, 24 species were present in 1998, 20 in 1999, 29 in 2000, and 31 were present in 2001. Kochia was the predominate species at North Platte in 1998, with 100% occurrence. In 2001, kochia occurrence was 50% at harvest time in plots treated with glyphosate. The five weed species with the highest frequency of occurrence were longspine sandbur (89%), tumble pigweed (89%), green foxtail (72%), Virginia groundcherry (72%), and common purslane (69%). Tumble pigweed had the most biomass in the glyphosate-treated plots while longspine sandbur biomass was greatest in the non-glyphosate treated plots. At Colby, 35 species were present in September 2001. Puncturevine was the most frequent weed species in every plot. In the pigweed family, frequencies were in the following order: redroot >Palmer > tumble > waterhemp > prostrate. In the grass species, prairie cupgrass frequence was highest followed by green foxtail > longspine sandbur > barnyardgrass > windmillgrass > large crabgrass = witchgrass. Prairie cupgrass, which is tolerant to glyphosate, was absent prior to 2000. In no year was two applications of glyphosate after crop emergence enough to prevent seed production of late germinating weeds. In semiarid areas of the central Great Plains, crop canopies often are insufficient to prevent late germinating weed from producing seeds. These seeds replenish the soil seedbank and present future weed problems.