A WARM WELCOME TO THE NORTH CENTRAL WEED SCIENCE SOCIETY. William G. Johnson, Assistant Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

The city of St. Louis and state of Missouri welcomes the North Central Weed Science Society to the Hyatt Regency Hotel for its 57th annual conference. The purpose of this presentation is to highlight some of the history, demographics and agricultural productivity of the state of Missouri. The land area which now encompasses Missouri was originally discovered by French explorers in the 1600's and named the Louisana Territory in honor of French royalty during that era. Ste. Genevieve was established as the first white settlement in 1735 and Pierre Laciede founded St. Louis in 1764. The French and Spaniards battled for control of the Louisiana Territory during the late 1700's and eventually sold to the United States in 1803. Missouri became the 24th state in 1821 and became to be known as the gateway to the west because trailheads for the Santa Fe and Oregon trails were located in Independence, MO and the Pony Express mail route connected Missouri to California. The Gateway Arch was completed in 1965 as a memorial to this history. The state flower and bird are the hawthorn (genus Crataegus) and eastern bluebird, respectively.

Missouri has a population of about 5.6 million people with approximately 55% of the population residing in Kansas City, St. Louis, and Springfield. With a land area of 68,886 square miles, Missouri averages 81.2 people per square mile. There are 109,000 farms in Missouri with roughly 4.6 billion dollars in annual sales. Farms in Missouri raise a wide variety of livestock and crops. Approximately 59% of the receipts are from livestock and 41% are from crop sales. Missouri ranks in the top ten in crop productivity in grain sorghum (4th), hay (5th), rice and soybean (6th), watermelon and corn (9th), and cotton (10th). Missouri ranks in the top ten in livestock productivity in beef cows (2nd), turkeys (5th), milk cows (6th), hogs (7th), and broilers (10th).

Missouri has been a gracious host to the NCWSS annual conference 10 times between 1950 and 2002. The annual conference was held in Kansas City in 1953, 1971, 1987, 1993 and 2000 and in St. Louis in 1973, 1977, 1985, 1996, and 2002. Reasons for this include the centralized location and ease of transportation via airline travel.

Finally, weeds and weed science have had a profound influence on the history of this state. In 1899, Willard Duncan Vandiver made this statement at a political rally "I am from a state that raises corn, cotton, and cockleburs…..frothy eloquence neither satisfies nor convinces me. I am from Missouri…..you have got to show me!". This is widely believed to be the reason that Missouri has also become known as the "showme" state and indicates that even over 100 years ago, Missouri was famous for its weeds.

WEED SCIENCE: ARE WE ACHIEVING AS MUCH AS WE COULD? Roger Cousens, Professor of Crop Science and Head, School of Resource Management, The University of Melbourne, Victoria 3010, Australia

Comparisons of recent weed science papers and those from 10 or even 20 years ago indicate that we have not progressed very far. Although our work is technically excellent, we are still asking the same questions, using mostly the same, phenomenological, approaches. Few studies pose hypotheses or have objectives of generating understanding. It is argued that understanding, and therefore advancement in weed science, will come more rapidly from process-driven research, making use of the knowledge already generated from previous studies. Examples to support this view are presented from research on weed-crop competition, in particular on competitive crop cultivars, and on spatial pattern in weed populations.

2002 NCWSS PRESIDENTIAL ADDRESS. Dallas E. Peterson, Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Welcome to the 57th annual meeting of the North Central Weed Science Society. The annual meeting is the highlight of the year for the society where we come together as an organization to exchange information, make new acquaintances, and renew old friendships. The meeting also is the culmination of a lot of hard work by the local arrangements committee and program committees. I want to extend a special thank you this year to the local arrangements chair, Tom Peters, and to program chair and President Elect, Michael Horak for the tremendous job they have done preparing for this meeting. We have an exciting program and excellent facilities for our meeting this year, just as we have for the past 21 years that I have participated in this meeting.

I attended my first NCWSS meeting in 1981. I am always amazed when I think about the many changes that have taken place since that time. Research data was analyzed using a main frame computer with a card reader. Slides were painstakingly typed, and then photographed with a simple black on white format for the presentations. This all had to be done well in advance of the meeting. Today we can analyze data in the field with a computer that fits in the palm of your hand, and compose slick power point presentations and continue to make changes until we get to the meeting.

Likewise, our society has undergone and continues to experience tremendous change as well. I believe the North Central Weed Science Society has been the leader among our peer organizations at adopting new technologies and changing with the times. Some of the more recent changes include the shift to electronic presentations and publications. These changes have improved the quality and efficiency of operations. You've probably already noticed some of the new changes for this year. The research report and proceedings will be combined together on a single CD, which will be provided to everyone who registers for the meeting. The packaging of the two publications together and publishing them on a CD lowers the cost of publication and distribution. The proceedings and research report are now included as a part of registration for the meeting, which will simplify and increase distribution. The combined publications will be distributed in January, which will not sacrifice quality due to an early submission deadline, but will still be available in a timely manner. I feel this will be a positive change for both our members and the health of the society.

Many of the changes that have been implemented for 2002 were based on the recommendations of the Long Range Planning Committee, chaired by Past President Duane Rathmann, with much input from our publications editors Bryan Young, Bob Hartzler, and Bill Johnson. I want to thank the Long Range Planning Committee and the Editors for developing these plans. It is this kind of dedication and service from our members that makes our society successful. The same is true for all members who serve on committees and contribute their time and effort to the society. The society is here to serve its members, but certainly can not function without the many volunteer services of its members. It's also important to remember that every member's opinion is important. I would encourage everyone to participate in the member forum and provide input to the board members on how the North Central Weed Science Society can be improved in the future.

Much discussion took place at last years meeting regarding the future of the North Central Weed Science Society. Industry consolidation and smaller budgets in both industry and academia have put pressure on membership and meeting participation. However, a straw poll at last years general session indicated strong support for NCWSS to maintain its identity and continue with a similar meeting and organizational format. The Long Range Planning Committee and Board of Directors have taken this mandate into account as they develop plans for the future of the North Central Weed Science Society.

2002 North Central Weed Science Society Abstracts 57:6.

I have to confess that I could not remember much about the Presidential address or general session of my first NCWSS meeting. After reading through the "History of the North Central Weed Control Conference", I learned there actually was no general session of Presidential address that year because of the large number of papers. I mainly remember being very nervous and anxious about my presentation the first afternoon of the conference. At that time, I certainly had no idea or aspirations of serving in a leadership role in the society. I still find it hard to believe that I was given this opportunity. It's been a very rewarding experience and honor to serve as President of this society during the past year. I was surprised to learn that I was only the second person from the great state of Kansas to serve as president of this society. The first president from Kansas was Ted Yost, who is considered the father of this society and was the organizations very first president over 50 years ago. Thank you once again for the honor of serving as President of the North Central Weed Science Society.

VOLUNTEER OR FAILED WINTER WHEAT CONTROL IN THE SPRING WITH GLYPHOSATE, CLETHODIM, OR PARAQUAT + ATRAZINE.

Zach Deeds, Dallas Peterson, Kassim Al-Khatib, Phillip Stahlman, and Brian Olson, Graduate Research Assistant, Professor, Associate Professor, Professor, and Multi-county Extension Agronomist, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Control of volunteer or failed winter wheat in reduced or no-till cropping systems is an issue that must be addressed with the anticipated release of glyphosate resistant wheat. Field research was conducted at three diverse sites in Kansas to evaluate the effects of application timing and rate on glyphosate, clethodim, and paraquat + atrazine for control of wheat in the spring. Glyphosate, clethodim, and paraquat + atrazine were applied to wheat at the jointing and heading growth stages at 0.25X, 0.5X, 0.75, and 1X of the typical field use rate. The 1X field use rates were 1120 g ha^{-1} of glyphosate, 280 g ha^{-1} of clethodim, and 1050 g ha^{-1} of paraquat. All paraquat applications were applied with 1120 g ha^{-1} of atrazine. Glyphosate provided the most complete control of wheat with early applications. All rates of glyphosate eventually controlled the wheat; however, time required to control the wheat was progressively longer with reduced rates. Clethodim was slow to control the wheat, but eliminated seed production. Percent wheat control was similar among the rates of clethodim. Paraquat + atrazine controlled the wheat at higher rates with both timing applications. Wheat control with paraquat + atrazine was not complete at the 0.25X and 0.5X rates and did not prevent wheat seed production.

2002 North Central Weed Science Society Abstracts 57:8.

WEED CONTROL IN IMIDAZOLINONE RESISTANT WHEAT WITH IMAZAMOX. Mark M. Claassen and Dallas E. Peterson, Associate Professor and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Imidazolinone resistance in wheat, marketed under the Clearfield trade name, provides producers with a new option for the control of a wide spectrum of weeds. These include troublesome grasses such as rye and bromus species as well as winter annual broadleaves. Field experiments were established in the fall of 2001 at Hesston and Manhattan, Kansas, to evaluate crop safety as well as efficacy of application times and rates of imazamox herbicide alone and in combination with tank mix partners.

A Clearfield derivative of ‘Hondo’ winter wheat was planted with 20-cm row spacing at each location in early October. Fall treatments were applied in early to mid-November to 10 to15-cm wheat with 2 to 5 tillers; 5 to 7.5-cm cheat and downy brome with 1 to 3 tillers; 10 to15-cm rye with 2 to 5 tillers; and 2.5 to 10-cm bushy wallflower rosettes. Spring treatments were sprayed in late March on well-tillered, 10 to 15-cm wheat; tillered 5 to 10-cm cheat and downy brome; tillered 10 to15-cm rye; and 5 to15-cm bushy wallflower rosettes. Imazamox was applied alone at rates of 35 and 44 g/ha as well as at 35 g/ha in combination with 21 g/ha chlorsulfuron&metsulfuron or 140 g/ha dicamba. These treatments were compared with 29 g/ha flucarbazone sodium, 45 g/ha MKH 6561, and with 35 g/ha sulfosulfuron alone or in tank mix with 21 g/ha chlorsulfuron&metsulfuron. The effect of herbicides on wheat and weeds were evaluated visually at various times during the growing season. Crop response was further assessed by measurement of grain yield and test weight.

Minor crop injury in the form of chlorosis and/or stunting was observed with most treatments, but the addition of chlorsulfuron&metsulfuron to imazamox greatly increased the negative effect on wheat. Imazamox and competing herbicides controlled cheat with both fall and spring applications, but fall timing tended to be slightly more effective. The addition of chlorsulfuron&metsulfuron to imazamox tended to reduce the level of cheat control in the spring treatment. Only fall-applied imazamox provided effective control of downy brome and rye. All treatments controlled bushy wallflower. There was no imazamox rate effect on crop injury or weed control. Yields were enhanced by weed control at one location and reduced significantly by injury from imazamox plus chlorsulfuron&metsulfuron at the other. Most herbicide treatments improved apparent wheat test weight.

FIELD EVALUATION OF COMMON WATERHEMP FOR SUSPECTED RESISTANCE TO PROTOPORPHYRINOGEN OXIDASE-INHIBITING HERBICIDES.

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Protoporphyrinogen oxidase-inhibiting (PPO) herbicides have been the major weed management option available to farmers raising soybeans without postemergence (POST) use of glyphosate. There have been reports of poor common waterhemp (*Amaranthus rudis* Sauer) control with certain PPO herbicides. Research was conducted at a location in northeast Missouri with suspected resistance. This research evaluated the response of common waterhemp to preemergence (PRE) and POST PPO-inhibiting herbicides to determine resistance. POST applications of mesotrione at 0.11 kg ai/ha and dicamba/diflufenzopyr at 0.29 kg ai/ha controlled common waterhemp 99 and 72%, respectively. Fomesafen at 0.33 kg ai/ha, aciflourfen at 0.42 kg ai/ha, lactofen at 0.22 kg ai/ha, flumiclorac at 0.03 kg ai/ha, and carfentrazone at 0.009 kg ai/ha controlled common waterhemp 57, 34, 46, 26, and 14%, respectively, 21 days after treatment (DAT). A PRE application of isoxaflutole at 0.07 kg ai/ha, flumioxazin at 0.07 kg ai/ha, and sulfentrazone at 0.24 kg ai/ ha controlled common waterhemp up to 4 WAT. Control remained above 90% up to 6 WAT and then declined over time. PRE treatments of isoxaflutole, flumioxazin, sulfentrazone were then treated with lactofen at 0.22 kg ai/ha to determine the population of plants resistant to this herbicide. Control of the original population ranged from 43 to 61%. The POST PPO-inhibiting herbicides caused minor leaf necrosis, and regrowth from axillary buds was observed.

POSTEMERGENCE COMMON WATERHEMP CONTROL WITH MESORIONE AND DICAMBA + DIFLUFENZOPYR IN CORN. Joseph C. Cordes and William G. Johnson, Graduate Research Assistant and Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211.

The frequency of late herbicide applications increases when environmental conditions do not allow for timely applications. Dose response curves must be evaluated for adequate late season weed control. Greenhouse studies were conducted with the objective to evaluate the dose-response curve of mesotrione and diflufenzopyr + dicamba on 30-cm tall common waterhemp (*Amaranthus rudis*). A secondary objective was to analyze if synergistic activity was present when atrazine was added to mesotrione. Common waterhemp was planted in 15-cm pots and thinned to 1 plant pot^{-1} at 14 days after planting. Herbicide rates were 0.06 to 2x of the recommended labeled rate (61.52 g ha $^{-1}$ of diflufenzopyr + 153.8 g ha^{-1} of dicamba and 105.2 g ha^{-1} of mesotrione). Atrazine was applied at 0.56 kg ha^{-1} alone and with all rates of mesotrione. At 14 days after treatment (DAT) plants were harvested and the dry weights were compared to the untreated plants to determine the percent growth reduction. The GR_{50} and GR_{80} values were calculated from regression lines and the Colby multiplicative survival model was used to determine if the interaction between mesotrione and atrazine was synergistic. The GR_{50} values for mesotrione and diflufenzopyr + dicamba was 8 and 57% of the 1x rate respectively. The GR_{80} value for mesotrione + atrazine was 27% of the 1x rate. When atrazine was applied alone it provided 22% growth reduction. The Colby analysis determined that the mean expected value for growth reduction with mesotrione + atrazine was 77% while the mean observed value was 82%. The analysis determined that the addition of atrazine to mesotrione was synergistic ($\alpha = 0.05$).

POKEWEED CONTROL IN CORN. Allen D. Sasse, George F. Czapar, Pablo Kalnay, University of Illinois, Springfield, IL 62791.

A study was conducted to evaluate post emergence control of pokeweed (*Phytolacca americana* L.) in corn. Dekalb RX 738 Roundup Ready corn was planted into a field with a natural infestation of both seedling and perennial pokeweed. Treatments were applied at approximately V5 corn stage. Seedling pokeweed were 25 cm tall, while perennial pokeweeds were 100 cm tall. The experimental design was a randomized complete block with three replications. The treatments included foramsulfuron, diflufenzopyr+dicamba+foramsulfuron, foramsulfuron+primisulfuron, mesotrione, glyphosate and an untreated check. The plots were evaluated 14 and 31 days after treatment for both seedling and perennial control. Glyphosate provided 100% control of both seedling and perennial plants. Diflufenzopyr+dicamba+foramsulfuron provided 93% control of seedling pokeweed and 88% control of perennial pokeweed. The foramsulfuron applied by itself had less than 70% control of both the perennial and seedling pokeweed.

EFFECT OF PLANTING DATE AND GROWTH RATE ON CORN TOLERANCE TO FORAMSULFURON ± ISOXADIFEN-ETHYL. Jeffrey A. Bunting, Christy L. Sprague, Emerson D. Nafziger, and Dean E. Riechers, Graduate Research Assistant, Assistant Professor, Professor, Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Two field studies were conducted at DeKalb and Urbana, IL in 2000 and 2001 to 1) evaluate the effect environmental conditions have on corn tolerance from applications of foramsulfuron with and without the safener isoxadifen-ethyl, 2) evaluate the effect leaf area and corn growth stage have on corn tolerance from applications of foramsulfuron with and without isoxadifen-ethyl, and 3) determine what effect isoxadifen-ethyl has on corn recovery from applications of foramsulfuron. All experiments were kept weed-free. Application rates of foramsulfuron were 37 g/ha. To study the effect of environmental conditions, corn was planted at three different dates and applications were made twice when one of the planting dates reached V6 corn. The three planting dates resulted in corn stages that ranged between V2 and V10 at the two application timings. There was a significant interaction between location and treatment ($P<0.05$) for the planting date study. Corn growth stages for the early-postemergence timing were V2, V4 and V6 and V6, V8 and V10 for the late-postemergence timing. At Urbana there was no significant corn injury. However, at DeKalb corn injury from the early-postemergence timing was greatest at the V6 stage followed by V4 and V2, regardless of the addition of isoxadifen-ethyl. Corn injury also was greatest for the V6 corn from the late-postemergence application timing. Regardless of growth stage at foramsulfuron application corn yield was not different from the non-treated control. The effect of leaf area was studied to examine the increased corn response at the V6 stage. Selected corn plots were cut at the V2 stage resulting in an 80% reduction of biomass. Herbicide applications of foramsulfuron with and without isoxadifen-ethyl provided similar results when applications were made to V6 stage corn at 100% biomass or 20% biomass. Visual corn height recovery was quicker for the 20% biomass plants. However, there was no difference in corn injury recovery between corn plants treated with foramsulfuron and those treated with foramsulfuron plus isoxadifen-ethyl. Regardless of corn injury, there was no impact on corn yield at the end of the season. From these experiments, it appears that applications at the V6 growth stage greatly affect corn's tolerance to foramsulfuron.

EFFICACY OF MESOTRIONE PREMIXES IN CORN. Patrick W. Geier and Phillip W. Stahlman, Assistant Scientist and Professor, Kansas State University Agricultural Research Center, Hays, KS 67601.

An experiment conducted near Hays, KS in 2002 compared the efficacy and crop tolerance of mesotrione premixes in corn. The premixes included mesotrione&*S*-metolachlor at 187&1870 or 224&2240 g/ha and mesotrione&*S*-metolachlor&atrazine at 187&1870&700 or 224&2240&840 g/ha, each at two times of application. Preemergence applications of the premixes were applied alone, whereas early-postemergence (EPOST) applications included nicosulfuron at 17 g/ha. All treatments controlled redroot pigweed, Palmer amaranth, and narrowleaf lambsquarters >95% at 100 days after postemergence (POST) applications. Treatments containing atrazine controlled kochia 95% or more, and 85 to 90% without atrazine. Puncturevine control ranged from 78 to 88% and did not differ between treatments. Preemergence treatments controlled longspine sandbur <50%, whereas PRE followed by POST or EPOST treatments controlled sandbur 63 to 79%. Corn in plots receiving herbicide treatments was 43 to 63 cm taller and matured 5 to 7 days earlier than untreated corn. Corn treated EPOST or PRE followed by POST tended to be taller than corn in plots treated PRE alone. The two- or three-way premixtures applied PRE did not improve corn yields relative to nontreated corn. However, corn treated with isoxaflutole plus atrazine PRE, dimethenamid PRE followed by dicamba&atrazine POST, or the two- and three-way premixes plus nicosulfuron EPOST yielded 1460 to 2200 kg/ha more grain than untreated corn.

CORN RESPONSE TO MESOTRIONE AS AFFECTED BY SOIL-APPLIED ORGANOPHOSPHATE INSECTICIDES. James J. Kells, Corey J. Guza, Christina DiFonzo and Michael R. Jewett, Professor and Graduate Research Assistant, Department of Crop and Soil Sciences, and Associate Professor and Research Technician, Department of Entomology, Michigan State University, East Lansing, MI 48824.

A field trial was conducted in 2002 to examine the interaction between mesotrione and soil-applied organophosphate insecticides. No corn injury occurred from soil-applied mesotrione at 0.21 kg ai/ha regardless of insecticide treatment. No injury occurred from foliar-applied mesotrione at 0.11 kg/ha in the absence of insecticide. Significant corn injury occurred from foliar-applied mesotrione following soil-applied organophosphate insecticides. Severity of corn injury from foliar-applied mesotrione was as follows: terbufos (3 times normal rate – 4.41 kg/ha) in-furrow > terbufos (normal rate – 1.47 kg/ha) in-furrow > terbufos (normal rate – 1.47 kg/ha) T-banded > chlorpyrifos (normal rate – 1.47 kg/ha) T-banded. Corn injury from the mesotrione/organophosphate insecticide interaction did not affect corn yield.

CONTROL OF PROTOX-RESISTANT COMMON WATERHEMP IN CORN AND SOYBEAN. Douglas E. Shoup, Kassim Al-Khatib, and Dallas E. Peterson, Graduate Research Assistant, Associate Professor, and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Common waterhemp (*Amaranthus rudis*) is a major problem in corn and soybean production. Resistance to protoporphyrinogen oxidase (protox)-inhibiting herbicides was confirmed in 2001 in a population of common waterhemp that had been treated with acifluorfen for several years. The objectives of this research were to evaluate herbicide efficacy on protox-resistant common waterhemp in corn and soybean. In 2001 and 2002, experiments were conducted in the field where the protox-resistant common waterhemp biotype was found. Corn and soybean were planted according to Kansas State University Research and Extension recommendations. In soybean, postemergence application of protox-inhibiting herbicides acifluorfen and lactofen gave 14 and 24% common waterhemp control, respectively. However, application of preemergence protox-inhibiting herbicides flumioxazin and sulfentrazone gave 95 and 92% common waterhemp control, respectively. Alachlor, metolachlor + metribuzin, and glyphosate provided 100% common waterhemp control. In corn, flufenacet + atrazine, isoxaflutole followed by bromoxynil + atrazine, and mesotrione + metolachlor gave greater than 98% control of common waterhemp. The lowest common waterhemp control was with imazethapyr + imazapyr + diflufenzopyr + dicamba, which gave 65% control of common waterhemp.

INTERFERENCE EFFECTS OF WEED-INFESTED BANDS IN OR BETWEEN CROP ROWS ON CORN YIELD. William W. Donald, Research Agronomist, U. S. Department of Agriculture, Agricultural Research Service, and William G. Johnson, Assistant Professor, Agronomy Department, University of Missouri, Columbia, MO 65211.

The impact of season-long interference by mixed populations of weeds grown in bands either only in corn rows or only between rows on corn yield has not been reported before. Over three years in Missouri, the ranking of corn yields in response to four weed interference treatments were as follows: (IR + BR weed-free) ≥ (IR weedy only) ≥ (BR weedy only) ≥ (IR + BR weedy). In all three years, (IR + BR weed-free) yields exceeded those for either the (BR weedy only) or (IR + BR weedy) treatments, the two lowest yielding treatments. In two of three years, yields for the (IR + BR weed-free) treatment were greater than the (IR weedy only) treatment, but these two treatments were indistinguishable in a third year. In two of three years, the yields for (IR weedy only) treatment exceeded the (BR weedy only) treatment, but these treatments were indistinguishable in a third year. Finally, the yield of the (BR weedy only) treatment was indistinguishable from the (IR + BR weedy) treatment in two of three years. In a third year, the yield of the (BR weedy only) treatment exceeded that of the (IR + BR weedy) treatment. The ranking of the four treatments in terms of the between row total or grass weed ground cover, chiefly giant foxtail, was inversely related to the corn yield ranking. When bands of weeds grew in crop rows, but were controlled between rows, corn yield partially compensated for weed interference better than when weeds were controlled in crop rows, but not between rows. This research suggests that it may be more critical to control weeds between corn rows than in rows, but controlling weeds both in and between corn rows maximized yield.

EFFECT OF SOIL-APPLIED HERBICIDE APPLICATION TIMING ON FOXTAIL SPECIES CONTROL AND CORN YIELD. Damian D. Franzenburg, James F. Lux, and Micheal D.K. Owen, Agricultural Specialists and Professor, Department of Agronomy, Iowa State University, Ames, IA 50011.

Experiments were conducted near Ames, IA from 1999 to 2002 to determine the effect of application timing of several herbicides on weed control and corn yield. The experimental design was a randomized complete block with three replications for 1999, 2000, and 2001, and six replications for 2002. Plots were 3 by 7.6 m and experiments were planted with 76 cm row spacing on no tillage soybean ground. Acetochlor, dimethenamid, flufenacet & metribuzin, and s-metolachlor were included in the 1999, 2000, and 2001 experiments, and dimethenamid was replaced by flufenacet in the 2002 experiment. All herbicides were applied at labeled rates and were tank mixed with glyphosate at 0.84 kg/ha to control existing weeds. Applications occurred at approximately 60, 45, 30, and 15 days before planting (DBP) and preemergence (PRE), following planting. Dicamba was applied early postemergence at 0.56 kg/ha to all plots to control broadleaf weeds. Percent visual control of foxtail species was evaluated at four and eight weeks after planting. Giant foxtail was the primary species in 1999 through 2001, and a mix of green and yellow foxtail occurred in 2002. Plots were machine harvested and yield was corrected to 15.5% moisture.

In 1999, 2000, and 2001, foxtail species control was above 87% for flufenacet & metribuzin, regardless of application timing. Control was above 82% control for s-metolachlor, with the exception of 67% control at the 60 DBP timing in 2000. Acetochlor provided 82 to 95% control across timings in 1999 and 2001. However, in 2000 marginal control was provided at most timings and only 52% control occurred at 60 DBP. Dimethenamid provided less control each year at the 60 DBP timing than the other herbicides.

Application timing was determined significant when yield data was combined for 1999, 2000, and 2001. However, only the 60 DBP timing was significantly lower than the other timings. Yields from flufenacet & metribuzin were at least 10% higher than all other treatments when averaged over all application timings. There were no significant differences between the remaining herbicides, averaged across timings. There were no significant differences between herbicides at individual timings of 45 and 30 DBP and PRE timings. However, s-metolachlor and dimethenamid had significantly lower yields than others at 60 DBP, and acetochlor and s-metolachlor had lower yields for the15 DBP treatment.

Unlike 1999 through 2001 combined data, 2002 yields were very responsive to application timing. Heavy foxtail species pressure occurred in the 2002 experiment. PRE and 15 DBP timings yielded similarly and were followed by the 30 and 60 DBP. The 45 DBP timing provided the lowest yields. Flufenacet & metribuzin and flufenacet treatments yielded significantly higher than s-metolachlor and acetochlor when data was combined for 2002. S-metolachlor yielded significantly higher than acetochlor. There were also differences between herbicides at each timing.

The trend for corn yields could generally be predicted by weed control from combined data for 1999, 2000, and 2001. This trend was very strong for 2002. Weed control and corn yields improved from 45 to 60 DBP. Weed control and yield continued to increase for 30 and 15 DBP and PRE timings. The timing effect was significant ($P<0.05$) for data combining 1999 through 2001 and for 2002. However, differences were more pronounced between application timings during 2002, when much greater foxtail pressure existed. Considering all four years of data, 15 DBP and PRE timings consistently provided better foxtail control and higher corn yields.

FALL AND EARLY SPRING APPLICATIONS OF RIMSULFURON + THIFENSULFURON METHYL FOR WINTER ANNUAL WEED CONTROL IN CONVENTIONAL –TILL AND NO-TILL CORN. Kevin L. Hahn, Marsha J. Martin, Helen A. Flanigan and David W. Saunders, Field Development Manager—IL, Field Development Manager—OH and MI, Field Development Manager—IN and KY, and Product Development Manager—US, DuPont Crop Protection, Johnston, IA. 50131

Winter annual weed infestations have been increasing in Midwest crop production fields causing management problems in both conventional-till and no-till corn production. Field studies were conducted from 1998 through 2002 to determine the best weed control programs for managing winter annual weeds in conventional and no-till corn. Field studies revealed that fall or early-spring applications of rimsulfuron + thifensulfuron methyl (DuPont® Basis®) herbicide programs provided the broadest spectrum winter annual weed control and early season residual control of spring germinating summer annual weeds as compared to other herbicide programs. Field studies also revealed that fall or early-spring applications of rimsulfuron + thifensulfruon methyl programs could be utilized in combination with in-crop postemergence herbicide programs to provide season long weed control in commercial corn production fields. In a field study conducted from 2001 and 2002 in conventional-till corn, fall applications of rimsulfuron + thifensulfruon methyl programs effectively controlled heavy infestations of common dandelion. Areas treated with fall applied rimsulfuron + thifensulfruon methyl programs had average corn plant stands of 23,967 plants per acre while untreated areas had average corn plant stand counts of 17,300 plants per acre.

GLYPHOSATE EFFICACY: INFLUENCE OF ADJUVANTS AND TANK-MIXED PESTICIDES.

Brad K. Ramsdale, Sam J. Lockhart, and Calvin G. Messersmith, Postdoctoral Research Fellow, Research Specialist, and Professor, Department of Plant Sciences, North Dakota State University, Fargo, 58105.

Glyphosate use has increased greatly in recent years due to development of glyphosate-resistant crops. Glyphosate-resistant crops in North Dakota include soybean, corn, canola, and potentially hard red spring wheat in the near future. Accordingly, growers would desire to apply glyphosate with insecticides and fungicides to maximize the efficiency of their pest control operations. Numerous glyphosate products are currently available including glyphosate pre-mixed with various herbicides; glyphosate as isopropylamine, ammonium, and diammonium salts; and glyphosate formulated alone or with various adjuvants. Consequently, there are many issues regarding adjuvant recommendations to maximize efficacy of these new glyphosate products. Therefore, a series of field experiments were conducted in 2002 to examine the influence adjuvants, spray water quality, and tank-mixed insecticides and fungicides on glyphosate efficacy.

Bioassay species were seeded side-by-side with a small grain drill with one drill pass of each species per replicate, and plots 10 ft wide were laid out perpendicular to the strips so that each plot contained the seeded assay species. Treatments were applied at 8.5 gpa with a CO_2-pressurized bicycle-wheel-type plot sprayer equipped with four 8001 flat-fan nozzles at 20-inch spacing. Experimental design was a randomized complete block with four replicates, and each experiment was repeated at two or three locations. Glyphosate was applied at a reduced rate of 0.06 lb ae/A to better detect treatment effects on herbicide efficacy. Adjuvants, insecticides, and fungicides were applied at labeled rates. Weed control was evaluated visually where 0 equaled no visible injury and 100 equaled complete death of assay species. Experimental methods and environmental conditions at treatment are further described in individual reports published in the North Central Weed Science Society Research Reports Vol. 59.

Glyphosate as Roundup Custom was influenced less by insecticides and fungicides than Roundup UltraMax and Touchdown formulations applied with 1% w/v ammonium sulfate (AMS). The surfactant in Class Act Next Generation applied with Roundup Custom may have minimized any adverse influence of the tank-mixed pesticides. Overall, pesticides formulated as emulsifiable concentrates, particularly dimethoate and chlorpyrifos, were occasionally synergistic to the reduced glyphosate rate. Flowable formulations of pesticides were occasionally antagonistic to glyphosate; most notable was the fungicide azoxystrobin.

Spray water quality did not affect glyphosate (Roundup Custom) efficacy for various adjuvant-fertilizer blends, indicating that all contained a sufficient amount of AMS to overcome the antagonistic salts (1550 ppm $CaCO_3$) in the hard water source. The adjuvant-fertilizer blends were applied at a rate to provide 8.5 lb AMS per 100 gal water. Glyphosate (Roundup Custom), which does not include a surfactant, was most effective when applied with adjuvants that contained surfactant, which included L-283 (NDSU experimental adjuvant blend), Surfate, Class Act Next Generation, Bronc Plus, and One-Ap XL. The drift retardant-AMS blends of Corral AMS, Surf Plus, and Gardian Plus, which do not contain a surfactant, were generally the least effective. However, glyphosate with Placement Pro-Pak or Array was generally more effective than with the other drift retardant-AMS blends, except with One-Ap XL which also contains surfactant. Thus, with glyphosate (Roundup Custom), which does not contain a surfactant, adjuvant-fertilizer blends that contained surfactant were the most effective adjuvants for glyphosate.

All treatments in the glyphosate surfactant experiment were applied with a hard water carrier (1550 ppm $CaCO_3$). Glyphosate efficacy was best when applied with surfactants plus AMS at 1% w/v or surfactant-AMS blends. Glyphosate efficacy, when applied without AMS, tended to be greater when applied with Liberate, Atplus GTM-10, Purity 100, and LI-700 than other surfactants. However, results varied across location, evaluation date, and species.

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REFLECTANCE RESPONSE PATTERNS OF CORN AS AFFECTED BY PRE AND POST 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

To increase the ease of research being conducted in site-specific weed management and weed species identification via remote sensing, the impacts of herbicides on corn reflectance response patterns are being researched. It may be possible to find reflectance response patterns of individual weed species that would open the future to a broad expanse of possibilities in these fields. The identification of herbicides that do not impact the spectral response pattern of corn 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 costs required to study reflectance response patterns of weed/crop population dynamics.

Experiments were conducted at the Agronomy Research Center near West Lafayette, IN. PRE corn herbicide treatments evaluated were 3.6 kg a.i./ha acetochlor, 2.2 kg a.i./ha atrazine, 880 g a.i./ha flufenacet + 220 g a.i./ha metribuzin, 120 g a.i./ha isoxaflutole, 2.1 kg a.i./ha metolachlor, and 2.0 kg a.i./ha pendimethalin. POST corn herbicide treatments evaluated were 1.7 kg a.i./ha atrazine + .95 L/ha COC, 560 g a.i./ha bromoxynil + 1% v/v COC, 798 g a.i./ha. 2,4-D, 212 g a.i./ha dicamba + 83 g a.i./ha diflufenzopyr + 0.25% v/v NIS, 70 g a.i./ha nicosulfuron + 1% v/v COC, and 40 g a.i./ha primisulfuron-methyl + 0.25% v/v NIS. The herbicides were selected to represent a large percentage of the chemicals used in the Midwest and those that have varying modes of action that can result in various symptoms on the corn plants. This range of symptomology has the potential to create a broad range of plant reflectance response patterns.

Multispectral aerial images composed of three bands of reflectance were collected over the test areas from 6 to 11 weeks after planting, 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 5 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.

SAS PROC STEPDISC and PROC DISCRIM were used to identify and model up to twelve bands of reflectance from the data most useful for differentiating between individual herbicide treatments and untreated plots. The Fisher linear discriminant classifier in MultiSpec was used to classify treated plots in pair-wise comparisons with the untreated plots. Results show isoxaflutole and metolachlor PRE treated corn have the least effect on the spectral response. Pendimethalin treated plots were highly separable from untreated plots using SAS and image classification techniques. POST herbicide treatments atrazine and primisulfuron-methyl were found to have little or no impact on the spectral reflectance of corn. 2,4-D and dicamba + diflufenzopyr were found to have the greatest effect on the spectral properties of corn.

MANGANESE FERTILIZER ANTAGONISM OF GLYPHOSATE EFFICACY. Mark L. Bernards, Kurt D. Thelen, and Donald Penner, Graduate Research Assistant, Assistant Professor, and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824. (23)

Michigan soybean producers have observed an antagonism of glyphosate efficacy when it is tank-mixed with foliar manganese (Mn) fertilizers. The objectives of this study were to 1) document the basis for the observed antagonism of glyphosate activity when applied with Mn micronutrient solutions, and 2) develop recommendations for growers to effectively use foliar applied Mn with glyphosate in their soybean production systems.

Glyphosate was applied at 0.28 kg a.e. ha^{-1} to velvetleaf (*Abutilon theophrasti*) and giant foxtail (*Setaria faberi*) in greenhouse bioassays and at 0.84 kg a.e. ha^{-1} in field trials. Manganese was applied at 9.35 L ha^{-1} (liquid formulations) or 7.84 kg ha^{-1} (powder formulations) in both field and greenhouse studies. Three Mn formulations, Mn with ethylaminoacetate (Mn-EAA), Mn with lignin sulfonate (Mn-LS), and manganese sulfate monohydrate ($MnSO_4$), antagonized glyphosate efficacy in the greenhouse and the field (25-80% reduction). Manganese-ethylenediaminetetraacetate (Mn-EDTA) did not antagonize glyphosate efficacy. The adjuvants diammonium sulfate (AMS) and citric acid each reduced some of the antagonism in tank-mixtures with Mn-EAA, Mn-LS, and $MnSO_4$. However, the extent to which the antagonism was ameliorated depended upon the specific combination of Mn and adjuvant, and for most combinations a slight antagonism persisted when compared to glyphosate and AMS. Varying the rate of Mn fertilizer (2.34, 4.68, and 9.35 L ha^{-1} or 1.95, 3.9 and 7.8 kg ha^{-1}) tank mixed with glyphosate did not vary the antagonism of velvetleaf control caused by Mn-LS or $MnSO_4$. However, control with the 2.34 L h^{-1} Mn-EAA treatment was significantly greater than the two higher rates (38 % vs. 22% and 18% respectively, p=0.05).

To test if the antagonism is the result of reduced glyphosate absorption, the adaxial surface of the second leaf of velvetleaf was treated with two 1-µL drops of formulated glyphosate spiked with 127 Bq of ^{14}C-labeled glyphosate. Leaves were excised and rinsed at 4, 24, and 48 h. For the glyphosate check (averages of +/- AMS treatments) 19% of the applied glyphosate was absorbed by 4 h, 49% by 24 h, and 53% at 48 h. Absorption of the Mn-EDTA tank mixes paralleled those of the glyphosate check. Mn-EAA solutions were absorbed very rapidly, 42% within 4 h, with little absorption occurring thereafter. Absorption from the Mn-LS and $MnSO_4$ solutions was significantly lower than the glyphosate check at both 24 and 48 h (p=0.05). Adding AMS improved the absorption of glyphosate, Mn-LS, and $MnSO_4$ solutions. With one exception, the absorption data reflect the efficacy data: in the glyphosate, Mn-LS, and $MnSO_4$ solutions efficacy and absorption were both enhanced by adding AMS to the spray solution; glyphosate efficacy and absorption in solutions with Mn-EDTA were similar with and without AMS; the exception – glyphosate in Mn-EAA solutions was absorbed at rates equal to the glyphosate check, but weed control efficacy was significantly less.

Not all Mn fertilizers antagonize glyphosate efficacy. Part of the Mn fertilizer antagonism is caused by reduced glyphosate absorption, but there are likely additional interferences not yet identified. For some Mn fertilizers this antagonism my be ameliorated (but not eliminated) by the use of AMS or a similar adjuvant in the tank mix solution.

USING MULTISPEC TO IDENTIFY WEED INFESTATIONS IN SOYBEANS. 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.

Remote sensing has been proposed as a tool for weed detection and several studies have demonstrated the ability of remote sensing technologies to accurately classify weeds in a variety of settings. One shortcoming for this technology is that classification models need to be constructed on a site to site basis. Some researchers have suggested that weed species may have unique reflectance properties that would allow researchers to associate particular wavelengths or suites of wavelengths with individual weed species. To determine whether wavelengths used to classify weed species at one site could be used to classify the same species at a second site, experiments were conducted at the Agronomy Research Center near West Lafayette, IN and the Davis-Purdue Agricultural Research Center near Farmland, IN. During mid-May 2001, velvetleaf (Abutilon t*heophrasti* Medicus), giant ragweed (*Ambrosia trifida* L.), common lambsquarters (*Chenopodium album* L.), and giant foxtail (*Setaria faberi* Herrm.) were seeded in 6-m by 6-m plots with and without drilled soybean [*Glycine max* (L.) Merr.]. Ground-based reflectance measurements were collected from both locations at or near soybean canopy closure using a field spectrophotometer positioned 7-m above the crop canopy. MultiSpec, a multispectral image data analysis system, was used to determine the effect of weed species, with and without soybeans, on reflectance properties of sample areas. Wavelengths selected at one location were generally useful in classifying treatments at a second location. Also, wavelengths associated with weed species grown in monoculture were generally useful in classifying weed species grown with soybean. Our results support the idea that wavelengths or suites of wavelengths can be associated with individual weed species.

ECONOMIC EVALUATION OF REDUCING PREEMERGENCE HERBICIDES FOR SITE SPECIFIC WEED MANAGEMENT. Tyler W. Rider and J. Anita Dille, Undergraduate Research Assistant and Assistant Professor, Department of Agricultural Economics and Department of Agronomy, Kansas State University, Manhattan, KS 66506

The objective of this study was to determine if it is economically feasible to reduce PRE herbicide application rates. Field tests were completed on Field 306 at the Kansas State University Agricultural Research Center, Hays, KS. A premix of 48% flufenacet and 10% isoxaflutole was PRE broadcast in strips at rates of 0, 0.133 kg/ha, 0.278 kg/ha, and 0.406 kg/ha. On 21-23 May 2002, weed species were mapped on a 7.6 x 7.6 m grid with species identified and counted in a 1 m2 quadrant at each grid point.

The weed species identified lead to the POST broadcast application of a tank mix of 0.001 kg/ha prosulfuron and 0.32 kg/ha sodium salt of diflufenzopyr on 31 May 2002. Weed species were then mapped on the same grid on 12 July 2002 to evaluate the POST application. On 24 August 2002, the corn was harvested as silage. Dry silage weight/ha was recorded for the controls and each herbicide treatment.

Weed populations observed on 12 July 2002 were used to calculate competitive load values for each 7.6 by 7.6m cell. These competitive load values were used to estimate grain yield. Quadratic production functions were estimated from both the silage yield and estimated grain yield data allowing calculation of the economic optimal herbicide rate and to capture the possible negative relationship of applying too much herbicide.

Various production functions were estimated and the functions that explained the most variation in the data were optimized.

The rate of PRE herbicide that maximizes yield using the silage yield model was 0.69 the label rate. The PRE herbicide application rate that maximizes profit was 0.67 of the label rate where price of silage was $0.005/kg and price of herbicide was $0.06/kg. The rate of PRE herbicide that maximizes yield from the grain yield model was 0.71. The rate of PRE herbicide that maximizes profit was 0.63 of the label rate where price of corn was $2.09/bu and price of herbicide was $0.05/kg.

This study found that it was economically feasible to reduce PRE herbicide application rates and that the economic optimal application rate was near 0.67 of the label rate.

PREEMERGENCE HERBICIDE SCREENING FOR CUPHEA. Vince M. Davis*, Gordon K. Roskamp, and Winthrop B. Phippen, Student, Professor, and Assistant Professor, Agriculture Department, Western Illinois University, Macomb, IL 61455 USA.

Cuphea is a wild plant that may soon be a mid-western cash crop. Cuphea seed oil is rich in lauric acid. Lauric acid is a medium-chain triglyceride essential in the production of most soaps and detergents. Eight million acres of Cuphea would be needed to meet current US demand. One obstacle of commercial production of Cuphea is weed control. The identification of a preemergence herbicide will be vital to insure Cuphea as a viable commercial crop.

The objective of this project was to conduct a preemergence herbicide screening trial to identify suitable soil applied herbicides for the agriculture production of Cuphea. Preliminary greenhouse studies examined twelve herbicides. Isoxaflutole, mesotrione, benefin, trifluralin, pendimethalin, and imazethapyr were then tested in two randomized complete block field studies. Results indicate isoxaflutole has excellent Cuphea safety and weed control. Benefin, trifluralin, and imazethapyr appear Cuphea safe with mixed weed control, and mesotrione and pendimethalin cause slight concern of slower Cuphea growth. The identification of an effective preemergence herbicide will allow researchers to advance Cuphea as a new commercial crop.

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PERFORMANCE AND ECONOMIC COMPARISONS OF DIFFERENT GLYPHOSATE PRODUCTS IN GLYPHOSATE RESISTANT CORN AND SOYBEANS WEED MANAGEMENT SYSTEMS. David E. Hillger, Thomas T. Bauman and Michael D. White, Graduate Research Assistant, Professor and Research Assistant, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Studies were conducted in 2002 at the Purdue University Agronomy Research Center located northwest of West Lafayette, IN. Five different glyphosate formulations were tested at a rate of 0.84 kg ai ha^{-1} and 1.68 kg ai ha^{-1}. The formulations tested were: Roundup WeatherMax, Roundup UltraMax, Touchdown IQ, Glyphomax Plus and Clearout 41 Plus. WeatherMax is a potassium salt formulation, Touchdown is a diammonium salt and UltraMax, Glyphomax and Clearout are isopropylamine salt formulations. The weed control, crop response and grain yield for the ten different treatments were evaluated in glyphosate resistant corn and glyphosate resistant soybeans. The corn trials were conducted in a conventional tillage production system. An application of s-metolachlor at 1.44 kg ai ha^{-1} and atrazine at 1.86 kg ai ha^{-1} was applied preemergence. The soybean trials were conducted in a no-till production system. The different glyphosate formulations were tested as a burndown application and as a post emergence application in the soybeans. The weed species present included giant foxtail, velvetleaf and ivyleaf morningglory. The weed control resulting from the preemergence application in the corn was excellent, resulting in very low weed pressure at the time of post emergence application. The weed control for the burndown and post emergence applications in the soybeans did not produce significant differences between treatments. The glyphosate treatments did not produce significant differences in the crop response for either the corn or soybeans. Yields were not significantly different between treatments in the corn or soybeans. Therefore it can be concluded that for the weed species present and growing conditions observed, the glyphosate formulation used did not significantly impact the performance of the corn or soybeans.

WEED IT --- WEED INFORMATION TRANSFER FOR EDUCATIONAL FUCNTIONS. Jingkai Zhou, Janet Davidson-Harrington, and Calvin G. Messersmith, Department of Plant Science, North Dakota State University, Fargo, ND 58105.

Weed IT is a comprehensive software application being developed for growers, extension agents, consultants, students, and researchers who want to get North Dakota weed control information. The primary goal of this application is building a convenient tool to retrieve weed control information from an efficient database. The database contains original field research data and information rich data. To achieve this goal, the system architecture of Weed IT consists of four integrated components: weed field research database, weed control information, user interface, and function modules. Weed IT is implemented as a multi-functional tool providing a wide range of potential application in weed science education, extension, and research. The educational functions provide weed, herbicide, and weed control information through a series of interfaces such weed identification, herbicide information, annual weed control, perennial weed control, sugarbeet weed control, resistant weed management, and crop rotation restriction.

JOINTED GOATGRASS: A THREAT TO WINTER WHEAT PRODUCTION. Tony White, Extension Coordinator, National Jointed Goatgrass Research Program, Kansas State University Agricultural Research Center, Hays

Jointed goatgrass (*Aegilops cylindrica*) was introduced into the United States during the early 1900s and has spread throughout most of the winter wheat producing areas in the west. Jointed goatgrass is a devastating weed that infests over 5 million acres of winter wheat and is spreading unchecked at a rate of nearly 50,000 acres per year. Jointed goatgrass costs producers $145 million annually due to reduced grain yields – commonly a 25% to 50% loss - and increased dockage at the grain terminal.

In 1994, the National Jointed Goatgrass Research Program initiated an integrated, multidisciplinary effort involving 11 states and over 35 state and federal scientists to battle the problem of jointed goatgrass in winter wheat. Projects focused on management practices, certain aspects of jointed goatgrass biology and ecology, and various components of transferring the information directly to producers. The goal of the program is to ensure that producers have the best and most recent information possible to successfully manage jointed goatgrass in winter wheat.

Jointed goatgrass is difficult to control in winter wheat. It typically emerges simultaneously with the wheat crop in the fall and is similar in appearance to wheat, so the problem often is not identified. Jointed goatgrass produces spikelets (sometimes called joints) that are about the same size as wheat, making them difficult to clean from wheat seed and increasing the chance that the weed seed is planted with the crop the following year.

Valuable data regarding jointed goatgrass biology and management has been gathered through this research initiative. Research indicates that interrupting the life cycle of jointed goatgrass with spring seeded crop rotations or other cultural practices may provide effective control. Long term research in many wheat producing states has discovered the Best Management Practices (BMPs) for controlling jointed goatgrass.

During the next several years, this national program will focus on technology transfer activities, conclusion of systems research projects, and new research to fill important jointed goatgrass data gaps. Greater emphasis will be on technology transfer during the last two years of the initiative, which is scheduled to conclude in 2006. Additional information regarding the management and biology of jointed goatgrass or other aspects of this initiative can be found online at *www.jointedgoatgrass.org*.

OCCURRENCE AND MANAGEMENT OF EASTERN BLACK NIGHTSHADE WITH PERENNIAL CHARACTERISTICS. Bryan G. Young, Scott A. Nolte, and James R. Martin, Assistant Professor and Graduate Research Assistant, Department of Plant, Soil, and General Agriculture, Southern Illinois University, Carbondale, IL 62901 and Extension Professor, Department of Agronomy, University of Kentucky, Princeton, KY 42445.

Eastern black nightshade (*Solanum ptycanthum*) usually exhibits an annual growth habit but it can also behave as a short-lived perennial. Perennial eastern black nightshade plants were reported in a single county in western Kentucky in 1993, but this isolated problem did not appear again in 1994. In 2001 perennial plants were identified over a large region including western Kentucky, southern Illinois, southern Indiana, and southeast Missouri after numerous growers experienced management problems with eastern black nightshade. Investigations were conducted on the biology and distribution of perennial eastern black nightshade and postemergence herbicide efficacy in soybean. The perennial plants have most commonly been found in no-tillage fields on well drained soils. Some excavated plants displayed root structures that spread for several feet to produce new plants. Berries were produced from early June through November. Perennial eastern black nightshade plants survived much longer in the fall than annual plants and the berries remained green until the plant entered winter dormancy. In most cases, plants exhibiting perennial characteristics in 2001 did not survive and grow in the spring of 2002.

Anecdotal reports from growers suggested that soybean herbicides traditionally effective on eastern black nightshade did not provide complete control of perennial plants. Field studies were conducted in 2001 and 2002 at a site in White County, Illinois where perennial plants had been identified in the spring of 2001. Herbicide treatments evaluated included imazamox (44 g ai/ha), fomesafen (395 g ai/ha), glyphosate (840 and 1300 g ae/ha), and glyphosate (1300 g/ha) plus imazamox (44 g/ha). Herbicides were applied July 13, 2001 and July 23, 2002 when perennial eastern black nightshade plants were 30 to 60 cm and 25 to 71 cm in height, respectively. Fomesafen and imazamox controlled 10 and 65% of perennial plants, respectively, at 28 days after treatment in 2001. However, perennial eastern black nightshade control was 94% from both fomesafen and imazamox at 28 days after treatment in 2002. Glyphosate controlled at least 90% of perennial eastern black nightshade by 28 days after treatment in both years. New perennial nightshade growth was observed in glyphosate treated plots at the end of season in 2001. Drought conditions following herbicide application in 2002 may explain the differences in perennial eastern black nightshade response to herbicides between years.

EASTERN RED CEDAR CONTROL IN NEBRASKA PASTURE. Stevan Z. Knezevic, Assistant Professor, Haskell Ag. Lab., University of Nebraska, Concord, NE, 68728-2828, Adam Kantrovich, Assistant Professor, Morehead State University, Morehead, KY 40351, and Robert 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 at two locations in 2001 and one location in 2002 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. Treatment efficacy declined with increased tree height. Eastern redcedar control was greatest when picloram was a component of 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 462 g ae ha^{-1} + fluroxypyr at 462 g ae ha^{-1} (5 pints $acre^{-1}$), picloram at 454 g ae ha^{-1} + 2,4-D at 1680 g ae ha^{-1} (6 pints $acre^{-1}$), picloram at 605 g ae ha^{-1} + 2,4-D at 2240 g ae ha^{-1}(8 pints $acre^{-1}$), or picloram at 560 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.[33]

FLUROXYPYR EFFICACY AS AFFECTED BY RELATIVE HUMIDITY AND SOIL MOISTURE. Mark D. Lubbers, Phillip W. Stahlman, and Kassim Al-Khatib, Graduate Research Assistant, Professor, and Associate Professor, Kansas State University Agriculture Research Center, Hays, KS 67601 and Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Efficacy of postemergence herbicides is often influenced by environmental conditions. Fluroxypyr currently is registered for postemergence use in small cereal grains. It effectively controls several annual broadleaf weed species commonly found in grain sorghum. Because environmental factors may influence the effectiveness of fluroxypyr, a study was conducted to determine the effects of relative humidity and soil moisture on fluroxypyr phytotoxicity to two weed species. Kochia and Palmer amaranth were planted in pots and placed in growth chambers with a constant relative humidity of 35 or 90%. Within each relative humidity, plants were watered at a soil moisture regime of either -20 or -40 kPa. Soil moisture was maintained throughout the study by weighing and watering pots daily. When plants were 10 cm tall, fluroxypyr was applied at 0, 26, 53, 79, or 105 g ae ha^{-1}. Visual control was determined 7, 14, and 21 DAT. At 21 DAT, both species were controlled more when grown at 90% RH compared to 35% RH, regardless of soil moisture. Kochia control differed between -20 and -40 kPa only when grown at 35% RH, with more control at -20 kPa. In contrast, Palmer amaranth control differed between -20 and -40 kPa only when grown at 90% RH, with more control at -20 kPa. Fluroxypyr applied at 26 g ae ha^{-1} controlled kochia more than Palmer amaranth; however fluroxypyr applied at 79 and 105 g ae ha^{-1} controlled Palmer amaranth more than kochia.

RAPID ASSAY OF PLANT RESPONSE TO PROTOPORPHYRINOGEN OXIDASE (PROTOX) - INHIBITING HERBICIDES. Jeanne S. Falk, Kassim Al-Khatib, and Dallas E. Peterson, Graduate Research Assistant, Assistant Professor, and Professor, Department of Agronomy, Kansas State University, Manhattan, Kansas 66506.

Protoporphyrinogen oxidase (protox)-inhibiting herbicides are an integral part of conventional soybean cropping systems. Resistance to protox-inhibiting herbicides was confirmed in a population of common waterhemp near Sabetha in northeast Kansas in 2001. The common approach to confirm protox resistance is to treat plants with selected rates of protox-inhibiting herbicides in the field or greenhouse. This method can be time consuming and costly. In order to quickly confirm resistance, a rapid assay is needed. Two procedures were tested for the rapid assay of soybean response to protox-inhibiting herbicides. Procedure 1 consisted of submerging leaf discs of soybean in solutions containing different concentrations of acifluorfen, fomesafen, or sulfentrazone. Leaf discs were incubated under a light intensity of 980 μmol m^{-2} s^{-1} for 3 hours. In procedure 2, the entire leaf of the soybean was treated with 0.0625, 0.125, 0.25, and 0.50 times the use rate of acifluorfen (420 g/ha), fomesafen (420 g/ha), and sulfentrazone (111 g/ha). The leaf was cut into discs and placed in a petri-dish on filter paper. Leaves were incubated at a light intensity of 245 μmol m^{-2} s^{-1} for 6 hours. Then leaf discs were submerged in an aqueous solution and incubated in darkness for 2 hours. In both procedures, herbicide damage was determined by measuring electrolyte leakage from leaf discs. Percent leaf disc leakage was determined by comparing electrolyte leakage to total electrolytes in the leaf discs. Response from procedure 2 for acifluorfen, fomesafen, and sulfentrazone was highly correlated with whole plant response to these herbicides. In procedure 1, the response for acifluorfen and fomesafen also correlated to the whole plant injury. However, the response of sulfentrazone was not well correlated with the response of the whole plant. These responses show that treating the entire leaf and incubating discs from the leaf in petri-dishes are more applicable to screening for resistance to protoporphyrinogen oxidase-inhibiting herbicides due to the direct correlation between electrolyte leakage and whole plant injury.

CHARACTERIZATION OF PROTOPORPHYRINOGEN OXIDASE RESISTANCE IN MISSOURI WATERHEMP (*Amaranthus rudis*). Jianmei Li[1], Reid J. Smeda[1], Kelly A. Nelson[2], and William G. Johnson[1]. [1]University of Missouri Columbia MO 65211; [2] University of Missouri Novelty MO 63460.

Resistance to PPO-inhibiting herbicides was suspected in two common waterhemp biotypes from Bethel and Meadville, Missouri. Greenhouse and growth chamber experiments were conducted to confirm resistance and also to delineate possible mechanisms of resistance. Pots studies were conducted with 13 to 18-cm plants treated with 0 to 3.36 kg ai/ha acifluorfen and 0 to 1.76 kg ai/ha lactofen. When compared to a known susceptible population, the Bradford biotype, the I_{50} R/S ratio was 28 for the Bethel biotype and 10 for the Meadville biotype treated with acifluorfen; the I_{50} R/S ratio was 44 for the Bethel biotype and 11 for the Meadville biotype treated with lactofen. In the growth chamber, leaf discs from both resistant and susceptible biotypes were pre-incubated in 30 μM aciflourfen in the dark for 20 h, exposed to light, and then periodically sampled for electrolyte leakage. Conductivity changes were found to increase steadily for the Bradford biotype treated with acifluorfen indicative of membrane disruption. However, little conductivity changes occurred for the Bethel biotype, and only moderate changes for the Meadville biotype. Results confirm resistance to PPO-inhibiting herbicides exists in two biotypes of common waterhemp; the mechanism of resistance does not appear to be based upon altered uptake and translocation.

TWO DIFFERENT TRIAZINE RESISTANT MECHANISMS IN WATERHEMP: MANAGEMENT IMPLICATIONS. Bradley S. Dixon, William L. Patzoldt, and Patrick J. Tranel, Undergraduate Research Assistant, Graduate Research Assistant, and Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Studies were conducted on greenhouse-grown waterhemp plants to compare atrazine responses among populations that were segregating for resistance (SegR), uniformly sensitive (UniS), or uniformly resistant (UniR). Previous research has shown that the UniR biotype has a triazine-insensitive D1 protein, whereas the SegR biotype has a different triazine-resistance mechanism. Crossing experiments confirmed that the SegR resistance mechanism exhibits nuclear inheritance. Atrazine dose-response experiments revealed that the SegR and UniR populations were 16-fold and greater than 770-fold resistant, respectively, relative to the UniS population. The SegR population exhibited resistance to cyanazine, but not to metribuzin, linuron, or pyridate. Soil-applied atrazine treatments effectively controlled the SegR population.

MOLECULAR CHARACTERIZATION OF THE HPPD GENE FROM VELVETLEAF. Dean E. Riechers and Michelle M. Stanford, Assistant Professor and Undergraduate Research Assistant, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Herbicides that inhibit the enzyme 4-hydroxyphenylpyruvate dioxygenase (HPPD) are relatively new for weed management in crops, and include the commercially available compounds of mesotrione, sulcotrione, and isoxaflutole. These herbicides are effective at controlling many broadleaf and certain grass weed species. In particular, mesotrione and isoxaflutole are very effective for selective control of velvetleaf, lambsquarters, and pigweeds in corn. These herbicides are also effective at controlling ALS- and triazine-resistant weeds, since they target a new and novel site of action in plants. No herbicide resistant weeds have been reported to the HPPD inhibitors, so it was our research objective to provide molecular information about the HPPD gene and its expression patterns in sensitive weed species before resistance development occurs. Our studies to this point have focused on velvetleaf, which is extremely sensitive to mesotrione and isoxaflutole and has a history of developing resistance to other classes of herbicide chemistry.

Primers for PCR (polymerase chain reaction) were designed from conserved sequences in the HPPD gene from other plant species (barley, carrot, *Arabidopsis*, and *Coleus blumei*) that are reported in the GenBank database. A 1.2 kb PCR product was amplified from velvetleaf genomic DNA using these primers. This PCR product was ligated into a plasmid vector and sequenced. The velvetleaf DNA was confirmed to be a partial fragment of the HPPD gene by comparison with the other HPPD sequences in GenBank, and is the first reported HPPD gene sequence from a weed species of agronomic importance. Among plants, the velvetleaf HPPD gene demonstrated the highest homology with the *Arabidopsis* HPPD gene, and the lowest homology with barley HPPD. The velvetleaf HPPD gene has a small intron that interrupts the coding region in the same place as the *Arabidopsis* gene. An expression study was set up to examine HPPD mRNA levels in velvetleaf seedlings: plants were either untreated or treated with mesotrione postemergence, then either kept in the light or placed in the dark for 24 and 48 hours. This study will allow us to determine under what experimental conditions the HPPD gene is expressed, which will be useful for subsequent cDNA cloning and in determining how many HPPD gene(s) are present and expressed in velvetleaf.

EVALUATION OF SPECTROPHOTOMETRIC METHODS FOR SHIKIMIC ACID DETERMINATION IN PLANTS. Ian A. Zelaya and Micheal D.K. Owen, Graduate Research Assistant and Professor, Department of Agronomy, Iowa State University, Ames, IA 50011.

Glyphosate inhibits 3-phosphoshikimate 1-carboxyvinyl transferase (EPSPS; EC 2.5.1.19), causing an accumulation of shikimic acid in protoplasts of plant cells. Thus, shikimic acid accumulation is an indirect estimate of EPSPS inhibition by glyphosate, and in a pragmatic sense, represents a method to ascertain glyphosate drift to non-target plants, differentiate between injury attributable to EPSPS and non-EPSPS inhibiting herbicides, and corroborate glyphosate resistance in plants.

Spectrophotometric methods are based on the oxidation of shikimic acid with periodate to form *trans*-2-pentene-1,5,-dialdehyde-3-carboxylic acid, followed by alkalinization and optical density (OD) detection at 380 nm. No direct comparison of the sensitivity and reproducibility of methods for shikimic acid determination exists in the literature. In addition, reported methods use diverse plant sources with different moisture contents. A standardization of methods is reported, comparing the reproducibility and respective strengths and limitations of the methods.

Glyphosate-resistant 'Asgrow AG2901' and susceptible 'Asgrow A2833' soybean (*Glycine max* (L.) Merr.) and glyphosate resistant 'DeKalb 545' and susceptible 'Garst 8550' maize (*Zea mays* L) were treated with 0.83 kg ae ha^{-1} glyphosate when soybean (V2-V3) or maize (V3-V4) reached 10-12 cm tall. Visual herbicide injury, plant height, and plant samples were collected prior to treatment (PT) and five, 12, 24, 72, and 192 h after treatment (HAT). Plant height was determined by measuring the distance from the soils surface to the apex of soybean or the collar of the utmost expanded leaf in maize. Shikimic acid was determined in actively growing tissues, thus sampling comprised removing the apex and the youngest fully-expanded trifoliate in soybean and the basal 3-cm of the coleoptile in maize. Plant samples were placed in a plastic bag iced, and immediately chilled to –10 C until utilized. After storage in –10 C, samples consigned for dry tissue determination were dried at 35 C for 48 h. Shikimic acid extraction and determination followed the protocols developed by Cromartie and Polge (2000, *WSSA Abs* 40:12; Spec #1) and Singh and Shaner (1998 *Weed Technol* 12:527; Spec #2); determinations were conducted at –4 C and ambient temperature.

Oxidation by periodic acid changed the absorbance maxima of shikimic acid standards and plant extracts from 280 nm to 380 nm. Similar absorption spectra were obtained from *Sorghum bicolor* (L.) Moench, *Ambrosia trifida* L., *Eriochloa villosa* (Thunb.) Kunth, and *Helianthus annuus* L. extracts spiked with known concentrations of shikimic acid, suggesting that the methods are specific to this aromatic compound. Extinction of the chromophore was temperature and concentration dependant and followed a sigmoidal and standard decay model for Spec #1 and Spec #2, respectively. The –4 C treatment increased the chromophore half-life ($t_{½}$) by 2.0-2.3 fold for Spec #1 and 1.6-2.0 for Spec #2. Glyphosate at the sprayed rates abolished plant growth in susceptible varieties; statistical differences ($\alpha \leq 0.05$) were obtained after 24 HAT for soybean and 72 HAT for maize. Visual herbicide injury was apparent at 72 HAT and near plant death occurred at 192 HAT for either susceptible crop variety.

Accumulation of shikimic acid was apparent after 5 h of treatment and increased exponentially until the last evaluation time. While both methods effectively quantified shikimic acid in soybean or maize tissues, and their estimations correlated ($r^2 = 0.96$; $P \leq 0.01$), Spec #1 estimated more shikimic acid in identical samples than Spec #2. Untreated and treated glyphosate-resistant soybean contained 0.0 to 0.4 μmol ml^{-1} shikimic acid per g of tissue, suggesting that the turnover rate of the shikimic acid pathway in these plants was comparable. Both methods estimated more shikimic acid in soybean apices than maize coleoptile tissues, however a better correlation was obtained with maize ($r^2 = 0.95$; $P \leq 0.01$) than soybean ($r^2 = 0.90$; $P \leq 0.01$) samples. As expected, almost twice as much shikimic acid was detected in dry tissues compared to wet tissues of soybean and corn.

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The pattern of shikimic acid accumulation was consistent with the principle that glyphosate inhibits EPSPS; susceptible plants accumulated more of the unphosphorylated substrate of EPSPS than resistant plants. Methods were specific for shikimic acid and under the extraction protocol evaluated, permitted quantification of shikimic acid from plant sources. In addition, the methods were inexpensive and quick to perform. Future work will focus on evaluating the extraction and HPLC techniques reported Lydon and Duke (1988 *J Agric Food Chem* 36:813).

OCCURRENCE OF KOCHIA AND OTHER WEED SEEDS IN SUGARBEET LIME PILES. Terry Schulz, Karen Renner, Undergraduate Student and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824, and Jim Stewart, Research Manager, Michigan Sugar Company, Caro, MI 48724.

Waste lime is a byproduct of the sugar purification process at sugarbeet processing plants. This byproduct lime is often stockpiled near sugarbeet piling grounds and used by area farmers to increase the alkalinity of their soils. These large lime piles become infested with kochia (*Kochia scoparia*) and other goosefoot species. Kochia is well adapted to such high pH soil environments, thriving on these lime stocks and in some instances, completely covering them with vegetation. These weeds produce large amounts of seed which re-infest the lime stockpiles. Use of this waste lime as a soil amendment could result in weed seed being spread on farmer’s fields. Therefore, we determined if kochia and other weed seeds were present in lime samples taken from stockpile sites at different processing facilities. Two lime samples were taken at each site. Sample depths ranged from the surface to 20 cm. Ten sub-samples of 100 cc of lime were taken from each of the samples from each processing site. Lime sub-samples were added to 2 L of water, and measured amounts of Calgon and Epsom salts were used to break up lime aggregation and add buoyancy to the suspension. The contents were shaken in a 4 L graduated cylinder for 2 min, and the suspension was then allowed to settle until most of the seeds and organic matter floated to the top. The suspension was then poured through a fine mesh screen to filter out the seeds and organic matter. More water was added to the lime remaining at the bottom of the cylinder, and the filtering step was repeated. Weed seeds were then counted and identified with the aid of a microscope. Lime samples were incorporated into greenhouse potting mix and emerged weed species identified. Kochia seed was found in most of the lime samples at very low levels. Samples from the Caro site had elevated kochia levels, as did the sample taken from a kochia infested stock pile area at the Bay City site. Goosefoot (*Chenopodiaceae*) seed was the dominant seed recovered from all lime samples. Weed species included common lambsquarters (*Chenopodium album*), oak-leaved goosefoot (*Chenopodium glaucum*), and maple-leaved goosefoot (*Chenopodium hybridum*). Samples from aged lime at the Sebewaing and Croswell contained the most weed seed, showing the persistence of the seed of these weed species. Therefore applying lime to farmer’s fields will spread weed seed. Kochia seed numbers were very low, implying non-persistence of kochia seed. Seed of *Chenopodiaceae* species in the field could increase by 30 - 850 seeds/m^2 if 4.5 metric tons/ha of beet lime was applied.

HERBICIDE AND FUNGICIDE TANK MIXTURES FOR WEED AND DISEASE CONTROL IN SUGARBEETS. Ryan M. Robinson, Karen A. Renner, Undergraduate Student and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824, and Jim Stewart, Research Manager, Michigan Sugar Company, Caro, MI 48723.

Sugarbeet growers face many challenges. Root rot diseases and weed control are two serious production problems. One important sugarbeet disease in Michigan is *Rhizoctonia solani*. This disease can cause up to 50% yield loss in sugarbeets. Furthermore, the reduction in sugarbeet stands caused by *Rhizoctonia solani* leaves open areas where weeds can grow. Weeds are controlled by both pre- and postemergence herbicides. In Michigan, 40% of the sugarbeet acres are treated twice with postemergence herbicides (standard splits) and 60% of the acres are treated four to five times with postemergence herbicides applied as micro-rates. Micro-rates are reduced herbicide rates applied with methylated seed oil. Azoxystrobin is a fungicide used to control *Rhizoctonia solani* in sugarbeets. Tank mixtures of postemergence herbicides with a fungicide to control *Rhizoctonia solani* are of interest to growers. However herbicide/fungicide tank mixtures may cause injury to sugarbeet. The objectives of this study were to determine sugarbeet response to postemergence herbicides applied alone and in tank mixtures with azoxystrobin fungicide, determine if adjuvants influence sugarbeet response to tank mixtures of postemergence herbicides and azoxystrobin fungicide, and lastly, evaluate *Rhizoctonia solani* control in sugarbeets when azoxystrobin was applied to 8-10 leaf sugarbeets in a tank mixture with herbicides.

Research was conducted at the Saginaw Valley Research Farm and treatments were arranged in a randomized complete block design with four replicates. On April 26, 2002 Hilleshog 'E-17' sugarbeet seed was planted. Postemergence micro-rate herbicide treatments were applied four times, beginning when sugarbeets were at the cotyledon growth stage. Standard split postemergence herbicides were applied twice, beginning when sugarbeets had two true leaves. The Betamix standard split included desmedipham & phenmedipham (Betamix) at 0.56 kg/ha, triflusulfuron (UpBeet) at 0.017 kg/ha and clopyralid (Stinger) at 0.094 kg/ha. Progress standard splits included desmedipham & phenmedipham & ethofumesate (Progress) at 0.56 kg/ha, triflusulfuron (UpBeet) at 0.017 kg/ha and clopyralid (Stinger) at 0.094 kg/ha. Betamix micro-rates contained desmedipham & phenmedipham (Betamix) at 0.09 kg/ha, triflusulfuron (UpBeet) at 0.004 kg/ha, clopyralid (Stinger) at 0.023 kg/ha and an adjuvant. Progress micro-rates included desmedipham & phenmedipham & ethofumesate (Progress) at 0.09 kg/ha, triflusulfuron (UpBeet) at 0.004 kg/ha, clopyralid (Stinger) at 0.023 and an adjuvant. Both standard split and micro-rate postemergence herbicides were applied alone or with different adjuvants, including methylated seed oil (MSO) (micro-rates only), Kinetic, Induce, and Freeway. All adjuvants were applied at recommended rates. All treatments were applied with a tractor mounted sprayer delivering 187 L/ha at 207 kPa using XR8003 spray tips. Azoxystrobin fungicide was applied with the last herbicide treatment of the micro-rate and standard split treatments on June 13, 2002 when sugarbeets were at the 8-10 leaf stage. All sugarbeets were inoculated with *Rhizoctonia solani* 14 days following the last herbicide treatment.

Azoxystrobin increased sugarbeet injury from desmedipham & phenmedipham & ethofumesate (Progress) compared to Progress alone. Azoxystrobin increased sugarbeet injury from desmedipham & phenmedipham (Betamix) only in micro-rate treatments that included MSO. The addition of a nonionic surfactant increased sugarbeet response to standard split applications of desmedipham & phenmedipham (Betamix). Sugarbeet injury from micro-rates of desmedipham & phenmedipham (Betamix) and desmedipham & phenmedipham & ethofumesate (Progress) was greater with MSO compared to NIS if azoxystrobin was included. Azoxystrobin reduced *Rhizoctonia solani* infection resulting in greater sugarbeet stands and yields compared to herbicide only treatments.

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SENSITIVITY OF MINOR CROPS GROWN IN MICHIGAN TO ISOXAFLUTOLE CONTAMINATED IRRIGATION WATER. Eric A. Nelson and Donald Penner, Graduate Research Assistant and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Isoxaflutole is a preemergence herbicide used to control both annual grass and broadleaf weed species in corn. The labeled rates for isoxaflutole range from 75-140 g a.i./ha. Isoxaflutole is not currently labeled for use in the states of Michigan, Minnesota, or Wisconsin. One of the concerns regarding isoxaflutole and its metabolites is potential mobility in soil and that under high rainfall conditions contamination of groundwater may occur. Another concern is the sensitivity of many vegetable crops to isoxaflutole. A greenhouse experiment was conducted to evaluate and rank the sensitivity of nine minor acreage crops grown in Michigan to water containing known concentrations of isoxaflutole. Combined, the area of production of those crops in Michigan is over 550,000 ha.

The crops evaluated were: adzuki bean, alfalfa, carrot, cucumber, dry bean (navy and black beans), onion, sugarbeet, and tomato. Plants of each crop were grown in 11 by 11 cm pots filled with a Spinks loamy sand soil until they were approximately 15 cm tall. Once plants reached the 15 cm in height, they were treated with 2.5 cm of irrigation water containing isoxaflutole over the course of 1 hr. Isoxaflutole concentrations increased by a factor of two beginning at 6 parts per billion (ppb) for the most sensitive crops, navy and black bean. The highest concentration applied was 400 ppb, applied to onion. Each species was treated with three concentrations of isoxaflutole as well as an untreated control. Visible injury and plant height were evaluated 14 and 28 DAT, and dry weights were measured 28 DAT. Percent injury, height, and dry weights were regressed against isoxaflutole concentration. Percent visible injury resulted in the highest r^2 values. Therefore, visible injury was used to calculate GR_{20} values.

Of the crops evaluated, navy bean and black bean were the most sensitive and onion was the most tolerant to isoxaflutole. The concentrations of isoxaflutole required to cause a 20% level of injury to the crops 14 DAT were: Navy and black bean, 8 parts per billion (ppb); sugarbeet, 20 ppb; alfalfa, cucumber, and tomato, 43-47 ppb; adzuki bean, 60 ppb; carrot, 79 ppb; and onion, 238 ppb. The concentrations required to cause the same amount of injury at 28 DAT were lower, indicating lack of recovery between 14 and 28 DAT, injury increased instead. Navy, black, and adzuki bean exhibited the most severe increase in injury from 14 to 28 DAT. On a per-area basis, the tolerance of the crops to isoxaflutole applied in irrigation water when plants were 15 cm tall was much greater than for preemergence applications of isoxaflutole. It has been documented that as plants mature, their tolerance to a herbicide application often increases. Therefore, we can expect that if irrigation water contaminated with isoxaflutole was applied at earlier growth stages the sensitivity would be greater.

HERBICIDE SYSTEMS FOR IMPROVED WEED MANAGEMENT IN CUCUMBERS. Mathieu Ngouajio, Bernard H. Zandstra, William R. Chase, Mike Particka, Jeremy Ernest, and Joseph G. Masabni, Assistant Professor, Professor, and Research Assistants, Department of Horticulture, Michigan State University, East Lansing, MI 48824; Assistant Professor, Research and Education Center, University of Kentucky, Princeton, KY 42445.

Until now, weed control in cucumbers has relied on very few herbicides. New herbicides, including halosulfuron (Sandea) and the package-mix ethalfluralin plus clomazone (Strategy), have recently been approved for use in cucumbers. Evaluating the performance of these new herbicides as well as products registered on other crops would help improve weed management strategies in cucumbers.

Field experiments were conducted at Michigan State University, Horticulture Teaching and Research Center during summer of 2002 to evaluate herbicide systems for weed control in cucumber. Herbicides used included ethalfluralin, clomazone, naptalam, halosulfuron, sethoxydim, sulfentrazone, and s-metolachlor. Ethalfluralin and clomazone were mixed on the farm or purchased as the package-mix Strategy.

Halosulfuron and all combinations of ethalfluralin plus clomazone were very safe on cucumber. Less than 20% cucumber injury was observed after application, and the symptoms disappeared completely prior to crop harvest. S-metolachlor and sulfentrazone used alone or in combination with other herbicides caused over 50% cucumber injury and are therefore not acceptable for cucumber production. All herbicide treatments provided acceptable levels of weed control. However, weed control in plots treated with ethalfluralin or halosulfuron was significantly improved with the addition of clomazone or Strategy, respectively. Halosulfuron has little activity on grasses and on common lambsquarters and therefore cannot be used alone when those weed are important in the field. Our experimental plot had heavy infestations of common lambsquarters and grasses, which explain the relatively low level of weed control with halosulfuron. Sulfentrazone and s-metolachlor not only caused severe cucumber injury but also significantly reduced yields. Almost no fruit was harvested in plots treated with s-metolachlor or sulfentrazone applied postemergence. Yields in all other herbicide treatments were significantly greater than the untreated control. The combination of Strategy (ethalfluralin plus clomazone) and Sandea (halosulfuron) provided the most cucumber yield.

WEED CONTROL AND POTATO TOLERANCE WITH RIMSULFURON, HALOSULFURON AND SULFENTRAZONE PROGRAMS. Timothy Koch, Douglas Doohan and Joel Felix, Research Assistant, Associate Professor and Research Associate, Department of Horticulture and Crop Science, The Ohio State University, Wooster, OH 44691.

Weed control and potato tolerance were evaluated with POST applications of rimsulfuron plus metribuzin and sulfentrazone plus metribuzin, and with PRE and POST applications of halosulfuron. Target weeds included yellow nutsedge, common lambsquarters, Pennsylvania smartweed and giant ragweed. Results indicate excellent control of lambsquarters and smartweed with rimsulfuron plus metribuzin, with no potato injury. Sulfentrazone plus metribuzin provided similar smartweed control, but initially showed extensive potato foliage burn. However, crop yield was not affected. Halosulfuron provided excellent control of lambsquarters with PRE treatment and yellow nutsedge with split application (PRE/POST). Split application provided fair control of smartweed. Moderate stunting of the crop occurred initially with POST treatments of halosulfuron, but yield loss was primarily due to poor weed control.

PRE AND POST EMERGENT EFFECTS OF HALOSULFURON ON CERTAIN CUCURBIT SPECIES. Carlos D. Mayén and Stephen C. Weller, Graduate Research Assistant and Professor, Horticulture Department, Purdue University, West Lafayette, IN 47906.

Studies were conducted in the field to determine the response of cucumber 'Calypso', muskmelon 'Eclipse', pumpkin 'Jack of All Trades', summer squash 'Revenue', winter squash 'Mesa Queen' and watermelon 'Sangria' to pre-emergent and post-emergent applications of halosulfuron-methyl. There were two pre-emergent rates for halosulfuron, 14 and 28 g/Ha ; two post-emergent rates, 14 and 18 g/Ha ; the combinations of pre and post emergent applications with the respective rates; and a combination of ethalfluralin and clomazone at 5.6 L/Ha as the control. A split-plot design with 3 replications was adopted to allocate the two factors under study.

As a pre-emergent application, the higher rate of halosulfuron-methyl gave excellent weed control for 3 weeks. Crop vigor was similar for the lower rate of halosulfuron and ethalfluralin/clomazone, with a trend towards greater vigor reduction on most crops at the higher rate of halosulfuron. As a post-emergent application at 3 weeks after planting, halosulfuron provided excellent control of ragweed and velvetleaf, similar to the pre and post emergent combination. Post-emergent treatments did result in reduced crop vigor at all rates, yet cucumbers and muskmelons were more tolerant. The injury symptoms were yellowing and crinkling in the new emerging leaves, and had disappeared by 2 weeks after the post-emergent treatment. Only two crops were taken to yield, one representative of low phytotoxicity (cucumber) and one representative of high phytotoxicity (summer squash). For cucumbers, even though there was initial phytotoxicity caused by halosulfuron, the injury did not result in a delayed or reduced yield. For summer squash, there was a delay in the onset of fruit maturity and some reduction in accumulated yield due to post-emergent applications.

EVALUATION OF HERBICIDES FOR WEED CONTROL IN HORSERADISH. Elizabeth A. Wahle, Extension Educator, University of Illinois Extension, Edwardsville, IL 62025 and John B. Masiunas, Associate Professor, Department of Natural Resources and Environmental Sciences, University of Illinois, Urbana, IL 61801.

Weed management in horseradish is a major problem even though different control strategies such as cultivation, hand-weeding and herbicides are widely used. The currently registered herbicides (glyphosate, DCPA, oxyfluorfen, sethoxydim, and clethodim) do not control many of the common weeds occurring in horseradish production. DCPA, although widely used by growers for PRE grass control is inconsistent and costly. There are no POST broadleaf herbicides registered for horseradish. Sulfentrazone at 0.28 kg/ha PRE has recently been used on horseradish under Section 18 exemptions. Carfentrazone is another triazolinone herbicide being developed as a POST herbicide on a range of crops. If carfentrazone has adequate horseradish safety it might reduce the need for hand-weeding. Dimethenamid, currently being registered for crucifer crops including horseradish, dimethenamid will reduce reliance on DCPA and provide more consistent grass control. Our objective was to evaluate these herbicides for their crop safety and efficacy. The experimental design was a randomized complete block design with four replications. The field had a light and relatively uniform infestation of redroot pigweed (*Amaranthus retroflexus*), common lambsquarters (*Chenopodium album*), witchgrass (*Panicum dichotomiflorum*), and fall panicum (*Panicum capillare*). The '7586' cultivar of horseradish was planted on April 16. Each plot was 6 m long and contained three rows of horseradish.Herbicide treatments were applied using a CO_2 pressurized backpack sprayer fitted with 1.7 m wide hand-held boom that had four 8003 flat fan nozzle tips. The sprayer was calibrated to deliver 253 L/ha at 207 kPa. PRE herbicide treatments were applied on April 25 before crop and weed emergence. The POST treatments were applied on June 3 when the horseradish was 30 cm tall and the weeds were 15 to 30 cm tall and sparse. Crop injury was rated on June 3, June 26, and August 23 using a scale of 0 = no injury and 10 = complete plant death. Horseradish stand was counted on June 3. Weed control was rated on a scale of 0 = no control to 100 complete weed control. Weed control was based on the portion of the plot without weeds. Data were analyzed using the GLM procedure of SAS and means separated using Fisher's least significant difference (LSD) at 5%. Neither the PRE treatments nor the POST carfentrazone treatment injured the horseradish plants or reduced the stand compared to the untreated control. Weed populations were light and substantial emergence in even the control treatment did not occur until mid June, approximately 6 weeks after initiation of the research. Grass weeds were particularly uncommon in our research site and grass control was greater than 90% even in the untreated check plots. Broadleaf weed control was more varied but was still above 85% in the untreated check. Oxyfluorfen + sulfentrazone provided 95% or above control in both the early and late weed control ratings. The broadleaf weed control lasted longer and was better on August 23 in the combination treatment than oxyfluorfen alone but not sulfentrazone alone. Carfentrazone did not improve weed control compared to either the oxyfluorfen or sulfentrazone alone. This lack of improved weed control is likely because the low weed densities in our experiment would not normally justify a POST herbicide application. Dimethenamid alone and oxyfluorfen alone did not provide adequate broadleaf weed control through August 24 and should be combined with other herbicides for season-long weed control. Sulfentrazone alone or in combination with other herbicides has excellent safety for horseradish. Sulfentrazone also controls broadleaf weeds for a longer period than the older standard herbicide, oxyfluorfen. This longer length of control is critical because much of horseradish root size develops in August and September. Dimethenamid also has good safety on horseradish but will need to be combined with another herbicide for season-long weed control. Dimethenamid will likely improve grass control compared to either sulfentrazone or oxyfluorfen alone. Carfentrazone did not injury horseradish and would be welcome as a POST treatment to control broadleaf weeds.

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TEMPERATURE REGULATION OF SEED DORMANCY OF THREE WEEDS. Ramon G. Leon-Gonzalez* and Micheal D. K. Owen, Graduate Research Assistant and Professor, Iowa State University, Ames, IA, 50011.

Common waterhemp, giant foxtail and velvetleaf are three of the most important weeds in the Midwest United States. In a previous study conducted in Iowa, it was shown that these three species emerged at different times during the growing season. Giant foxtail emerged shortly after velvetleaf at the beginning of the growing season, and common waterhemp emerged several weeks after giant foxtail. We hypothesized that differences in the emergence characteristics of these weeds were due to differences in their temperature requirements for germination.

Seed germination of common waterhemp, giant foxtail, and velvetleaf in response to temperature was studied with a two-way thermogradient plate in order to evaluate responses to steady and alternating temperatures. The range of mean temperature evaluated was from 8 to 32 C with 2 C intervals. The amplitudes of temperature alternation analyzed were 0, 6, 12, 18, and 24 C.

Minimum and optimum temperatures for velvetleaf germination were approximately 8 and 24 C, respectively. Temperature alternation did not affect the germination of this species. The minimum temperature for common waterhemp germination was 10 C and 14 C for giant foxtail. The optimum germination of giant foxtail occurred at approximately 24 C, but common waterhemp optimum germination was variable depending on temperature alternation. The maximum temperature was not reached in the studied temperature range for any of the three species. Increasing the amplitude of the diurnal temperature alternation increased the germination of common waterhemp and giant foxtail, and this was more evident at lower mean temperatures. Amplitudes of temperature alternation 18 and 24 C promoted the highest germination. In addition, in the case of common waterhemp, the temperature required to reach specific germination percentages was reduced by increasing the amplitude of the temperature alternation. Therefore, temperature alternation played a very important role in reducing the dormancy level of common waterhemp and not only the number of dormant seeds.

The minimum and optimum temperatures shown by giant foxtail and velvetleaf were in agreement with the emergence timing that they show during the growing season. However, because temperature alternation reduced the optimum temperature of common waterhemp germination and the minimum temperature was only slightly higher than the other two species, one would expect common waterhemp emerging also at similar times than giant foxtail and velvetleaf. The results suggested that other factors besides alternation and mean temperature are important in controlling common waterhemp dormancy and germination.

GROWTH AND DEVELOPMENT OF ANNUAL WEEDS BY COHORT EMERGENCE TIMES IN CORN. Kathrin Schirmacher*, J. Anita Dille, Dale L. Fjell, and David L. Regehr, Graduate Research Assistant, Assistant Professor, Professor, and Professor, Agronomy Department, Kansas State University, Manhattan, KS 66506.

Variability in biological processes that drive weed population dynamics is poorly understood. Comprehending the extent of and factors that cause this variation will improve our understanding of basic weed biology, and is valuable when incorporated into computer-based weed management decision support systems. One biological process that varies is the relative time of crop and weed emergence. The objective was to determine the effect of corn growth stage on the emergence, development, and growth of four cohorts of eight annual weed species. Field experiments conducted near Manhattan in 2001 and 2002 documented time of 50% weed emergence, crop and weed heights, growth stages, and cylindrical volume of annual weeds. The eight weed species were common lambsquarters, common sunflower, Palmer amaranth, velvetleaf, fall panicum, giant foxtail, large crabgrass, and shattercane. Each experimental whole-plot included the eight species grouped by cohort, with cohort identified at a given corn growth stage (0, VE, V1, V3). In both years, and across weed species, cohorts planted earlier (0 and VE) indicated higher emergence, establishment and seasonal developmental rates. In the first cohort, all eight species emerged. Germination of common lambsquarters and fall panicum seed in 2001, and large crabgrass in 2002 failed to produce many seedlings in cohort 1 (0), and yielded no plants in cohorts seeded at VE, V1, and V3. The only species to emerge in cohort 4 (V3) were velvetleaf and shattercane, though some of these seedlings exhibited high mortality early in the growing season as environmental conditions shifted from wet to dry in both years. Overall, velvetleaf and shattercane were the earliest emergers within a cohort, followed by common sunflower and giant foxtail, which exhibited intermediate emergence times among the weeds studied. Common lambsquarters, fall panicum, large crabgrass, and Palmer amaranth revealed more erratic emergence profiles and were usually the last species to emerge within cohorts. In summary, results of this research indicated that emergence of seedlings differed among planting cohorts. Plants of earlier cohorts were more successful at completing their reproductive life cycles, more so than cohorts planted at a later corn growth stage.

EMERGENCE CHARACTERISTICS OF GIANT RAGWEED BIOTYPES FROM OHIO, ILLINOIS AND IOWA. Robert G Hartzler, Professor, Department of Agronomy, Iowa State University, Ames, IA 50011, Kent Harrison, Assoc. Professor, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210, and Christy Sprague, Asst. Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

While giant ragweed is found throughout the Corn Belt, it is a much greater problem in the eastern portion of this region than in the west. Independent research in Iowa and Ohio suggested that giant ragweed exhibits different emergence patterns in these states, and that these differences could partially account for the regional variation in problems caused by this weed. To test this hypothesis, seed from four giant ragweed biotypes were collected in Ohio, Illinois and Iowa. Three of the biotypes from each state were collected from agronomic fields, whereas the other was from a non-agricultural habitat. Experiments were established at each participating state in the fall of 2001 in which 500 seed of the 12 bioypes were buried in the upper 5 cm of soil contained within 30 cm diameter PVC pipes. Emerged seedlings were counted and pulled twice weekly throughout the 2002 growing season. Significant biotype and location effects occurred for all emergence parameters (initial date, cumulative emergence, duration and days to reach 95% emergence). Significant biotype by location interactions occured for several parameters, but were less than the main effects. All ag-biotypes from Ohio had similar emergence characteristics, and the Iowa ag-biotypes behaved similarly to each other and also to the three biotypes from undisturbed habitats. In contrast, two of the Illinois ag-biotypes had similar emergence characteristics to the Ohio ag-biotypes, whereas one Illinois ag-biotype behaved in a manner similar to the Iowa ag-biotypes. Cumulative emergence was less at Ohio (28 to 43%) than at Illinois or Iowa (40 to 57%). At the Illinois site there was a nine day difference in initial emergence dates among biotypes, with the biotypes collected in non-agricultural habitats emerging first (March 27). At Ohio and Iowa first emergence was recorded on March 17 and April 13 respectively, with a five day difference in emergence among biotypes at Ohio and only a two day difference at Iowa. The Ohio ag-biotypes and the two similar Illinois ag-biotypes were the latest to emerge at all locations. The total time period over which emergence occurred did not vary at Illinois, whereas at the other two locations the non-ag and Iowa ag-biotypes completed emergence in a shorter time period than the Illinois and Ohio ag-biotypes. The number of days required to reach 95% emergence varied more among biotypes than did the total duration of emergence. At the Ohio location, the biotypes from non-ag sites, the Iowa ag-biotypes and one Illinois ag-biotype reached 95% of total emergence in 29 days, whereas the three Ohio ag-biotypes and two Illinois ag-biotypes required 63 and 80 days, respectively. Similar responses were seen at the Iowa and Illinois locations. Early and rapid emergence can be disadvantageous to survival in corn and soybean fields since a high percentage of the plants emerge prior to normal planting dates and are killed by tillage or burndown herbicides. Ag-biotypes from Ohio, where giant ragweed is rated the number one weed problem, exhibited a later initial emergence date and more prolonged emergence than biotypes from Iowa where giant ragweed is much less of a problem. The Ohio emergence pattern is much more problematic for giant ragweed management than the pattern of Iowa biotypes. In Illinois, where giant ragweed has increased as a problem in recent years, giant ragweed populations were identified with both Ohio and Iowa emergence patterns. The distribution of biotypes with differing emergence patterns suggests an adaptation of giant ragweed for survival in agronomic fields that could result in increasing problems for farmers in the western part of the Corn Belt.

VELVETLEAF GROWTH IN MONOCULTURE AND IN SOYBEAN. Shawn M Hock*, Stevan Z. Knezevic, Alex R. Martin, John L. Lindquist. Graduate Research Assistant, Professor, Professor, Professor. University of Nebraska. Department of Agronomy and Horticulture. Lincoln, NE 68583-0915.

Velvetleaf is an important weed in row crops throughout the United States. This study was conducted to determine how soybean row spacing, relative time of weed emergence, and the presence of soybean influenced the growth of velvetleaf. Field studies were conducted at two locations in eastern Nebraska in 2002. Glyphosate resistant soybeans were planted in 19 and 76 cm row spacing. Velvetleaf was planted either in monoculture or with soybean at soybean planting (VP), emergence (VE), and 1st trifoliate (V2) growth stages. Velvetleaf emerged at cotyledonary (VC) and first nodal (V1) stages of soybean however, there was no emergence for velvetleaf when planted during soybean V2 growth stage. Crop presence was the most important factor influencing velvetleaf growth, resulting in a decreased dry matter (DM) and leaf area accumulation in mixed plantings. Soybean row spacing and relative time of weed emergence had a smaller affect on velvetleaf DM and leaf area accumulations by season end. Velvetleaf DM and leaf area was higher in wide-row than in narrow-row soybean. Velvetleaf planted at soybean VP had lower leaf area than velvetleaf planted at soybean VE.

ESTIMATING PLANT GROWTH IN MIXED SPECIES COMMUNITIES FROM MONOCULTURE EXPERIMENTS. Michael J. Moechnig*, David E. Stoltenberg, Chris M. Boerboom, and John M. Norman, Graduate Research Assistant, Associate Professor, Professor, Department of Agronomy, and Professor, Department of Soil Science, University of Wisconsin, Madison, WI 53706.

Traditional approaches of characterizing the relative competitive ability of plant species based on mixed species communities have been problematic in some aspects. These approaches are often labor intensive and results are often inconsistent among years and locations. Furthermore, few experiments address the influence of asymmetric competitive effects on relative competitive ability. Estimating plant competitive ability based on monoculture experiments may be less labor intensive and results may be more consistent. However, it has been difficult to apply the results from monoculture experiments to mixed species communities. One principal reason for this is the inability to accurately predict the plasticity of height growth, which is necessary for accurate estimations of light interception.

The plasticity of height growth may be influenced by light availability and the wind stress imposed on each plant. Plants growing in lower density communities are exposed to greater wind stress per plant, thus greater stem mass per unit of height is required for support. In higher density communities, wind stress is distributed among more stems resulting in greater height per unit of stem mass. Stem height growth is also a function of stem mass, which is determined by the quantity of available light for carbon assimilation. Therefore, height growth can be described as a function of light availability and wind stress. The objectives of this study were to parameterize a mechanistic model that characterizes the plasticity of height growth and use the model to determine whether plant growth interactions in mixed species communities can be estimated from monoculture experiments.

Common lambsquarters, giant foxtail, or corn monoculture experiments were established at the University of Wisconsin Arlington Agricultural Research Station in 2002. Density treatments were 4, 49, or 120 plants m^{-2} for common lambsquarters, 4, 64, 1000 plants m^{-2} for giant foxtail, and 3, 9, or 21 plants m^{-2} for corn. The experimental design was a randomized complete block with 3 replications of 4- by 4-m plots for each weed species or 6- by 6-m plots for corn. Plant height, leaf area, and biomass partitioning to leaves and structural material was measured from two plants per plot on a weekly basis for the first 6 wks after emergence and then biweekly until physiological maturity.

The mechanistic growth model was parameterized to accurately predict the density effect on biomass accumulation per plant and height growth in monoculture communities of each species. The parameterized model was validated using data from previous studies conducted at the Arlington Agricultural Research Station. The first study, conducted in 1998 and 1999, included a wide range of densities and species proportions of common lambsquarters and giant foxtail in corn. The second study, conducted in 2000 and 2001, included equal proportions of common lambsquarters and giant foxtail at one density planted at three different times relative to corn planting. Validation results indicated that the model accurately characterized the difference in common lambsquarters height when grown in corn compared to that in monoculture. Intraspecific interactions of weed communities in a corn canopy were also accurately characterized. Consequently, growth parameters estimated from monoculture experiments accurately predicted the effects of weed density and time of emergence on corn yield loss.

REPONSE OF THREE IOWA WEEDS TO NITROGEN TIMING AND CORN DENSITY. Matthew M. Harbur and Micheal D.K. Owen, Graduate Research Assistant and Professor, Department of Agronomy, Iowa State University, Ames, IA 50011-1010

Weeds may reduce crop yield responses to soil fertilization by immobilizing nutrients or by competing with the crop for other resources. It has been speculated that soil fertilization benefits all weeds , but this generalization ignores differences between weed species in emergence time, relative growth rates, seed reserves, and critical tissue nutrient concentrations, each of which may influence weed responses to nutrient availability in soil. A three-year study in Iowa compared the effect of pre-emergence (PRE N) and post-emergence (POST N) ammonium nitrate applications on the competitive abilities of giant foxtail, velvetleaf, and waterhemp in 'Pioneer 33V08' corn. The N timing effects were studied in corn densities of 5.4 and 7.9 plants per meter in order to understand the influence of other resources, including shading, on N response in weeds.

By late June of each year, PRE N had increased shoot dry weight by over 50% for corn, 100% for velvetleaf, and at over 20% for giant foxtail, compared to POST N. Common waterhemp was unaffected by N timing. Corn density increased corn shoot dry weight by 21 to 32%, but had little effect on weeds. Corn density did not generally affect weed shoot dry weights when evaluated in late June.

Corn grain and weed seed yields were significantly affected by interactions between N timing and weed species. Corn yield was decreased 13 to 20% by velvetleaf for PRE N compared to POST N. Conversely, corn yield was decreased 12 to 15% by POST N compared to PRE N. Similarly, PRE N increased velvetleaf seed weight by 13 to 195% compared with PRE N, but decreased giant foxtail seed weight by 55%. Velvetleaf and giant foxtail seed weights with the greater corn density were decreased by 23 to 56% and 30 to 62%, respectively. Neither N timing or corn density affected corn yield loss or weed seed production in treatments that included common waterhemp.

The results suggested that weed responses to N supply vary widely among species, but that N management can play an important role in reducing early-season weed competitiveness and late-season weed seed production in corn.

COMPERITIVENESS OF PALMER AMARANTH AND VELVETLEAF IN RESPONSE TO PREEMERGENCE HERBICIDE. Konanani B. Liphadzi and J. Anita Dille, Graduate Research Assistant and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66502.

Growth and competitiveness of weeds that escape a preemergence herbicide might be reduced due to herbicide injury. As a result, expected crop yield loss from escaped weeds should be less than that of uncontrolled weeds. Field experiments were conducted at Ashland Bottoms, KS (2001 and 2002) and Rossville, KS (2002) to quantify corn yield loss in response to Palmer amaranth or velvetleaf with and without isoxaflutole and/or flumetsulam, and to determine seed production from these two weed species. Palmer amaranth and velvetleaf were established at a density range of 0 to 6 and 0 to 32 plants m^{-1} of corn row, respectively. In the absence of either isoxaflutole or flumetsulam, corn yield loss increased with increasing density of both Palmer amaranth and velvetleaf. At Rossville 2002, Palmer amaranth that escaped through either isoxaflutole or flumetsulam caused 25% corn yield loss at a density of 6 plants m^{-1}. In contrast, yield loss from untreated Palmer amaranth at the same density was 38%. At Ashland Bottoms 2002, velvetleaf (6 plants m^{-1}) that escaped through flumetsulam reduced corn yield by 6% compared to 54% yield reduction with untreated velvetleaf at the same density. When treated with herbicide, seed production by Palmer amaranth and velvetleaf were reduced by 27% and 95%, respectively, compared to untreated weeds. The study showed that corn yield reduction from both Palmer amaranth and velvetleaf that escape through a preemergence herbicide is less than from untreated weeds. Moreover, seed production from escaped weeds was also reduced.

GIANT RAGWEED COMPETITIVENESS IN SOYBEANS AS INFLUENCED BY POSTERMERGENCE GLYPHOSATE APPLICATIONS AND ROW SPACING. 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.

Giant ragweed is becoming an increasing problem in Illinois production fields. Additionally, control failures with postemergence herbicides have become more prevalent throughout the state. In 2001 and 2002, field experiments were conducted to: 1) evaluate giant ragweed's competitiveness with soybeans planted in three different row spacings 2) evaluate the competitiveness of giant ragweed injured by postemergence applications of glyphosate, and 3) evaluate growth and seed production of surviving giant ragweed plants. At the University of Illinois' Northern Illinois Agronomy Research Center in DeKalb, 3 by 9 m plots of glyphosate-resistant soybeans were grown in a randomized complete block design with four replications. Soybeans were planted in row-spacings of 76, 38, and 19 cm and treated with 0.84, 0.42 and 0.21 kg ae/ha of glyphosate all containing 1.0% w/w AMS. Giant ragweed that emerged after the herbicide application was removed by hand-weeding. Giant ragweed competitiveness and regrowth was not affected by soybean row spacing. However, soybean yield and giant ragweed growth was significantly affected by the application rate of glyphosate. In 2001, 0.42 and 0.21 kg ae/ha of glyphosate reduced soybean yields by 31% and 65%, respectively. While in 2002 the same rates of glyphosate reduced soybean yields 27% and 20%, respectively. Glyphosate applied at 0.42 and 0.21 kg ae/ha did not effectively control giant ragweed. Plants that survived these applications produced 273 and 485 seeds per plant, respectively. Although 0.84 kg ae/ha of glyphosate provided 95% or more control of giant ragweed there were a few plants that survived and produced as much as 100 seeds per plant. Giant ragweed plants injured by herbicides still have the ability to compete effectively with soybeans and cause dramatic yield reductions.

STABILITY OF RADIATION-USE EFFICIENCY FOR ESTIMATING WEED BIOMASS ACCUMULATION IN WEED-CORN COMMUNITIES. Greta G. Gramig, David E. Stoltenberg, and John M. Norman, Graduate Research Assistant, Associate Professor, Department of Agronomy, and Professor, Department of Soil Science, University of Wisconsin, Madison, WI, 53706.

Simplified mechanistic models focusing on critical determinants of competitive outcomes can potentially provide useful descriptions of weed-crop competition with less difficult and cumbersome parameterization than more complex eco-physiological models. Competition for light is often a key determinant of competitive success in highly productive agroecosystems. Plant species convert intercepted radiation into biomass with varying degrees of efficiency. Variation in radiation-use efficiency (RUE) can result from intrinsic physiological differences among plant species and from differences in canopy light environments. Characterizing variation in RUE resulting from crop-weed interactions in complex canopies is necessary for making accurate estimations of weed biomass accumulation.

Field experiments were conducted in 2001 and 2002 to determine the RUE of giant ragweed, velvetleaf, woolly cupgrass, and wild proso millet grown in two competitive environments: weed monoculture or within corn. 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. Early-season weed species RUE values were calculated for each plot as the slope of cumulative intercepted photosynthetically active radiation (IPAR) (MJ $m^{-2}s^{-1}$) vs. cumulative shoot biomass (g m^{-2}) from emergence to V6 corn. IPAR was calculated as a function of leaf area index (LAI) and an estimated light extinction coefficient (K_d), which was based on a spherical leaf angle distribution and LAI. Daily estimates of plant biomass and LAI were interpolated from regression models with growing degree-days as the independent variable. Mean RUE values were tested for significance using the appropriate F-tests.

In 2002, an experiment was conducted to compare the above method of estimating IPAR with direct measurements of IPAR. Radiation sensors were placed above and below the canopy in 24 plots to measure IPAR over a 24-hour period. Paired t-tests comparing measured values of IPAR with estimated values of IPAR indicated no difference between methodologies (p=0.6586). Therefore, estimated values of IPAR were used for calculations of RUE.

F-tests of weed species RUE means indicated significant year by community (p=0.0423) and community by species (p=0.0003) interactions. Consequently, weed species RUE means in corn and in monoculture were compared within year using t-tests. In 2001, RUE of giant ragweed did not differ between communities (p=0.1292), but the RUE of velvetleaf (p=0.0102), woolly cupgrass (p<0.0001), and wild proso millet (p=0.0030) was greater in corn than in monoculture. In 2002, RUE of giant ragweed (p=1.000) and velvetleaf (p=0.0999) did not differ between communities but RUE of woolly cupgrass (p=0.0155) and wild proso millet (p=0.0462) was greater in corn than in monoculture. These results indicate that variation of weed species RUE was associated with the effect of corn on the canopy light environment. Weed species typically had greater RUE in corn than in weed monocultures except when the weed species was highly competitive with corn for light.

USING LEAF NITROGEN CONTENT TO PREDICT BIOMASS ALLOCATION PATTERNS 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

Knowledge of how plants will partition their new biomass will aid in understanding competition between crops and weeds. 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. In 2001 each plant received one of three nitrogen treatments: 0, 1 g, or 3 g of nitrogen applied as ammonium nitrate. In 2002 each plant received 0, 2, or 6 g of nitrogen. Measurements of total above and belowground biomass and tissue carbon and nitrogen concentration were made at 10 different sample dates during the growing season. By using these measurements, actual results were compared to the predicted results of a model to see if the model can be used to correctly predict the amount of plant biomass allocated to roots and shoots. The tested model has potential as a reliable tool for predicting plant biomass allocation patterns. Biomass partitioning was correctly predicted for corn in 2001 and 2002 and for velvetleaf in 2001.

THE EFFECT OF HABITAT HETEROGENIETY, CHARACTERIZED BY SOIL ORGANIC CARBON, ON GROWTH AND REPRODUCTIVE FITNESS OF COMMON SUNFLOWER. Rachelle R. Fargo, John L Lindquist, David A. Mortensen, and Daniel T. Walters, Graduate Research Assistant and Professors. Department of Agronomy and Horticulture, University of Nebraska, Lincoln, NE 68583-0817.

Research was conducted to determine the effects of soil organic carbon on growth and reproductive fitness of corn and common sunflower. Field experiments were conducted in 2001 and 2002 at the Agricultural Research and Development Center (ARDC) near Mead, Nebraska. Experimental design was a split plot with soil organic carbon as main plots and isoxaflutole presence or absence subplots. Isoxaflutole was applied at 1 and 15 g ha^{-1}. Common sunflower was seeded adjacent to the crop row. Biomass of common sunflower was obtained twice throughout the growing season; corn biomass was obtained at anthesis. Leaf area of common sunflower and corn were also measured. Sunflower inflorescences were counted and diameters were measured to determine reproductive fitness. Common sunflower biomass, leaf area, and seed production increased with increasing amounts of soil organic carbon. At low dosages of isoxaflutole, plant response did not vary across the soil the soil organic gradient. This indicates that there will be a greater abundance of common sunflower in environments with higher amounts of soil organic carbon. Corn yield loss owing to common sunflower interference may be greater in high soil organic carbon environments.

FIELD-BASED EVALUATION OF PST INTERACTIONS WITH CANADA THISTLE IN NON-DISTURBED SITES. Ryan P. Tichich and Jerry D. Doll, Graduate Research Assistant and Professor, Department of Agronomy, University of Wisconsin, 1575 Linden Drive, Madison, WI 53706.

Canada thistle's perennial membership on the noxious weed lists of many states testifies to it's resilience against conventional control tactics. This holds especially true in non-disturbed sites, where there are limited management tools. In addition, few of these tools are effective in the long run and those that are have a high cost and are often not justifiable in these systems. However, non-disturbed sites are more suitable for biological control agents than annual cropping systems as complete control is not required in the short term and if the agent can curtail the spread of the pest it can be considered successful.

PST (*Pseudomonas syringae* pv. *tagetis*), a bacterium that infects many plants in the *Asteraceae,* is pathogenic to C. thistle. Research has demonstrated the higher the PST population on the leaf surface, the higher the infection probability. Multiple applications at high bacterial concentrations control C. thistle because the PST population is kept artificially high for an extended period of time. As these treatments are costly, this strategy has not been developed commercially. Our research explores a new technique to spread the bacterium by harvesting naturally infected thistles, extracting their sap, and mixing it into a spray solution with an organosilicone surfactant. Specifically, 65 grams of naturally infected C. thistle shoots were blended into a liter of water, the solution was filtered, Silwet (L-77) was added at 0.3% v/v, and the solution was applied via a backpack sprayer fitted with extended range flat fan nozzles. A preliminary study with this method suggested that the spreading of the whole "system" instead of just the bacteria favors the infection process. Field trials were conducted in 2001 and 2002 to further test this strategy by evaluating the concentration of sap, spray volume, number and timing of the applications into the PST/C. thistle system. We measured disease incidence, disease severity, and growth inhibition of treated plants.

PST concentration and spray volume did not significantly impact the level of disease observed. This suggests that PST applications could be practical at the field scale, as a single application can cause infection. However, multiple applications proved to be beneficial as four consecutive weekly applications provided more infection than one or two applications. Applications in mid July achieved optimal infection (versus mid June or mid August)

Research by microbial ecologists on a different P. *syringae*S pathovar (pv. *syringae*) demonstrated that raindrop momentum was correlated with population explosions. It is seems reasonable to apply this concept to the PST/C. thistle system. Correlating results of these experiments to rainfall events during the 2001 and 2002 growing seasons reveals that treatments which were successful (July 15 and four applications) applications were followed by a rain within 10 days. Less successful applications occurred during extended dry periods.

For PST to become a more effective biocontrol agent, levels of disease incidence must be increased. Manipulating inputs into the PST/C. thistle system seems to have limited effects success in achieving this output. We need an increased understanding of the "black box" of the interaction between PST and the C. thistle leaf surface to increase disease incidence. Specifically, we need to identify additional PST population promoting factors (such as rain events). We also need to determine what factors constrain the PST population on the leaf surface, and to develop methods to manipulate them to support a higher population.

INTERACTION OF PURPLE DEADNETTLE AND SOYBEAN CYST NEMATODE. S. Kent Harrison, Ramarao Venkatesh, Emilie E. Regnier, and Richard M. Riedel, Associate Professor, Postdoctoral Research Associate, and Associate Professor, Department of Horticulture and Crop Science, and Professor, Department of Plant Pathology, Ohio State University, Columbus, OH 43210.

Purple deadnettle is a winter annual weed of no-tillage crop fields and serves as an alternate host of the soybean cyst nematode (SCN). Microplots were inoculated with SCN in spring 2001, and two experiments were established on the inoculated site to determine the effects of (1) purple deadnettle emergence time and (2) purple deadnettle removal time on SCN population development in continuous no-tillage soybeans. In the emergence time experiment, purple deadnettle was seeded weekly into SCN-infested plots beginning on 8/30/01 through 10/11/01. In the removal date experiment, purple deadnettle was seeded in all plots on 9/7/01, then hand-removed on 10/9/01, 10/25/01, 11/5/01, 11/21/01, 3/21/02, 4/11/02, 5/6/02, or not removed and allowed to reach full maturity. In both experiments, plots were soil-sampled just prior to establishment of PDN treatments in fall 2001, then again following soybean harvest in September 2002 to compare the single-year effects of purple deadnettle treatments versus weed-free soybean and plant-free controls. SCN population data (eggs+juveniles/200 cm^3 soil) for 2001 and 2002 were log-transformed prior to analysis, and SCN population growth is expressed as Pf/Pi, the ratio of the final to the initial SCN population. Actual SCN populations across both experiments increased from a mean value of 409 eggs + juveniles/200 cm^3 in 2001 to 2619 eggs + juveniles/200 cm^3 in 2002. Results from the planting date study indicated no significant treatment differences at an alpha level of 0.05. Plots seeded with purple deadnettle on all planting dates except 8/30/01 resulted in mean Pf/Pi values ranging from 1.26 to 1.54, compared to 1.12 for weed-free soybean and 0.84 for the plant-free control. The earliest planting date (8/30/01) produced poor purple deadnettle establishment and a low over-wintering weed population (<5 plants/m^2), resulting in a Pf/Pi value of 0.96. First-year treatment effects in the purple deadnettle removal time study were also non-significant at the 0.05 alpha level. Removal dates of 10/9 or later resulted in mean Pf/Pi values ranging from 1.35 to 1.72, compared to 1.12 for weed-free soybean and 0.84 for the weed-free control. Across both experiments, inherent among-plot variability in SCN counts contributed to the lack of significant treatment effects, although some treatments were significant at an alpha level of 0.1. Across both experiments, all PDN treatments except one had higher mean Pf/Pi values than the controls, so it is possible that statistical differences due to PDN may not become evident until additional PDN growing cycles occur.

FALL APPLIED HERBICIDES FOR WEED MANAGEMENT IN NO-TILL SOYBEAN. Romina Güeli and Reid J. Smeda, Graduate Research Assistant and Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211

Glyphosate resistant crops have been one of the most rapidly adopted techologies in agriculture since their commercial release in 1996. Weed control programs in soybean have shifted dramatically to postemergence applications, reducing the use of preplant and preemergence products. Lack of residual activity has contributed to winter annuals developing in fields late in the summer.

Field experiments were conducted at two Missouri locations (central and northeast) to evaluate the efficacy of fall applied versus conventional spring burndown and preplant herbicide programs for winter and summer annual weed control and soybean yield. Fall treatments were applied in mid-November 2001, and included: different rates of sulfentrazone (0.081, 0.114, and 0.15 kg ai/ha) and chlorimuron (0.017, 0.023, and 0.03kg ai/ha) plus tribenuron-methyl (0.0053 kg ai/ha); sulfentrazone, chlorimuron, tribenuron-methyl plus thifensulfuron (0.0017 kg ai/ha); and glyphosate alone at 0.84 kg ae/ha. Also in the fall, 2,4-D at 0.56 kg/ha a.i. plus crop oil crop concentrate was added for initial broadleaf control. Spring treatments included preplant applications of glyphosate alone at 0.84 kg ae/ha or with sulfentrazone plus chlorimuron. All plots received an application of glyphosate five weeks after planting or when weeds were 10-20 cm tall, to allow early but not late-season weed competition.

Percent weedcontrol was evaluated for winter and summer annual weeds in early March, April, May and two weeks after soybean planting (early May). Henbit, horseweed, field pennycress, shepherd's purse, and common chickweed control was 90 to 100% and similar for most applied treatments up to early May. However, control of summer annuals such as giant foxtail, common lambsquarters, and Pennsylvania smartweed in early May was inconsistent. The presence of winter weed residues together with wet conditions delayed soybean planting in central Missouri, and led to high populations of summer annual weeds following planting. Delayed planting also led to variable results with soybean yield. At Bradford, use of sulfentrazone plus chlorimuron and tribenuron-methyl, and glyphosate alone provided yields among fall applied treatments that were 17% higher than spring and pre-plant applications. Yields for spring applied glyphosate plus sulfentrazone and chlorimuron were 16% lower than some fall applied treatments at Novelty and up to 60% lower than the same fall applied treatments at Bradford. At Novelty, yields of pre-plant applications of glyphosate were the highest and comparable to the highest yielding fall applied treatments. Overall winter annual weed pressure at planting was 50 % greater at Bradford compared to Novelty.

SOYBEAN ROW SPACING AND PLANT POPULATION AFFECT EMERGENCE AND GROWTH OF EASTERN BLACK NIGHTSHADE. 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. Eastern black nightshade is considered to be a shade tolerant weed, implying that emergence and growth may not be influenced by shade beneath the soybean canopy. In 2001, eastern black nightshade emerged only during the first six weeks after soybean planting and emergence was not affected by row spacing or soybean population. Eastern black nightshade densities of 37/ m^2 did not reduce soybean yield in 2001. Research was continued in 2002 to determine if soybeans planted in narrow rows at higher plant populations would reduce eastern black nightshade emergence, biomass, and reproduction and to determine if eastern black nightshade would reduce soybean yield.

Research was conducted at Clarksville and East Lansing, Michigan. The experiment was arranged in a split plot design with row spacing as the main plot and soybean population as the subplot. Soybeans were planted at East Lansing on May 15 and at Clarksville on May 22, 2002 in 76 cm rows with a seeding rate of 185,000, 308,000, and 432,000 seeds/ha and in 19 cm rows with a seeding rate of 308,000, 432,000, and 556,000 seeds/ha. Eastern black nightshade seed was spread across the fields to insure a uniform population. Emergence of nightshade was recorded weekly throughout the growing season. Light measurements were taken every 7-14 days perpendicular to the soybean row to estimate soybean LAI. Micro-plots were established at both locations to study the effect of soybean population and row spacing on nightshade growth and development. Soybeans were thinned to exact populations and nightshade biomass measurements were taken on July 10, August 8, and September 27 at Clarksville and July 9, August 6, and October 1 at East Lansing. Soybeans were harvested on October 1st at both locations following the removal of all eastern black nightshade plants prior to harvest.

Eastern black nightshade emergence in May and June was not influenced by soybean row spacing or population. However, planting soybean in 19 cm rows reduced eastern black nightshade density and dry weight throughout the growing season, regardless of soybean population. Furthermore, berry dry weight in August and October was significantly reduced in 19 cm compared to 76 cm rows at Clarksville and East Lansing.

Fifty five percent of eastern black nightshade biomass was allocated to berry production in the 76 cm row spacing compared to 14% in the 19 cm rows in October. Eastern black nightshade densities of 4 plants/ m^2 did not reduce soybean yield, regardless of row spacing or soybean population at East Lansing. Soybean yields were reduced by nightshade densities of 5/ m^2 at Clarksville where soybeans were planted at 185,000 seeds/ha in 76 cm rows and at 308,000 and 556,000 seeds/ha in 19 cm rows. Soybeans should be planted in 19 cm rows to reduce eastern black nightshade biomass and seed production.

SOYBEAN RESPONSE TO SIMULATED DRIFT AND SPRAY TANK CONTAMINATION OF PLANT GROWTH REGULATOR HERBICIDES. Kevin B. Kelley, Loyd M. Wax, Aaron G. Hager, and Dean E. Riechers, Graduate Research Assistant, Professor, and Assistant Professors, Department of Crop Sciences, University of Illinois and USDA-ARS, Urbana, IL 61801.

Plant growth regulator (PGR) herbicides are very effective for weed control and are commonly used in corn and wheat production throughout the Midwest. However, soybeans are often grown in close proximity to corn and wheat fields and are very sensitive to PGR herbicides. Soybean demonstrating injury symptoms similar to those caused by PGR herbicides are commonly observed, and the increased use of postemergence herbicides has coincided with an increase in the frequency of these injury reports. Soybeans can be injured when a PGR herbicide moves off target either through spray drift or volatilization, or by residues dislodged from application equipment that was used for previous applications to a corn or wheat crop. This study evaluated the effects on soybeans of the commonly used PGR herbicides dicamba, dicamba + diflufenzopyr, 2,4-D and clopyralid. In 2001 and 2002, all four herbicides were applied at two ultra-low rates at two soybean vegetative growth stages and one early reproductive stage to simulate exposure by drift. In 2002, the commonly used soybean herbicides glyphosate, imazethapyr, imazamox and fomesafen were applied with and without 1% of a field use rate of dicamba at two vegetative growth stages to simulate tank contaminations.
Simulated drift of all four PGR herbicides caused significant soybean injury and plant height reductions. Soybeans were often able to compensate for the injury and reduced height through branching and yielded normally, though the level of injury and the probability of a yield response increased with higher rates. The severity of the response at different growth stages varied among herbicides. When comparing relative fractions of field use rates of these herbicides, increasing soybean injury followed the order dicamba > dicamba + diflufenzopyr > clopyralid > 2,4-D. Treatments including 1% of a field use rate of dicamba often resulted in a yield loss. However, when dicamba was combined with the commonly used soybean herbicides imazamox, imazethapyr and fomesafen at a late vegetative application, even greater soybean injury and yield loss occurred compared with dicamba applied alone. There was also a negative interaction at an early postemergence application between dicamba and fomesafen. Glyphosate did not have a negative interaction with dicamba at either application timing. These results indicate that soybeans can usually compensate for PGR herbicide injury and yield normally if they are not excessively stressed by an additional factor. When soybeans are additionally stressed by either a soybean herbicide or possibly an environmental stress, they are less able to compensate for the injury caused by a PGR herbicide than they would without the additional stress.

GUAR TOLERANCE TO VARIOUS POSTEMERGENCE HERBICIDES. Brian L. S. Olson, Multi-County Extension Agronomist, K-State University Northwest Area Research and Extension Center, 105 Experiment Farm Road, Colby, KS 67701; Todd A. Baughman and John W. Sij, Associate Professor and Professor, Texas A&M University Agricultural Research and Extension Center, PO Box 1658, Vernon, TX 76385.

A greenhouse study was initiated at the Texas A&M Research Center located by Vernon, TX to evaluate guar tolerance to various postemergence herbicides. Guar is a drought tolerant legume that does not have a postemergence herbicide labeled for use during the growing season with the exception as a harvest aid. Guar was grown in pots, thinned to one plant per pot, and herbicides were applied three weeks after emergence. A 1X and 2X application of the herbicides were applied at 140 L ha^{-1} at 276 kPa. All herbicide treatments had labeled rates of adjuvants and ammonium sulfate added as needed The study was repeated twice with six replications in each run. Visible injury and the dry weight of all above ground viable biomass for each plant was taken 28 DAT. Data were analyzed and a treatment effect was discovered. No difference was observed between the control which had no herbicide applied and 2,4-DB, bentazon, and imazethapyr in visible injury and dry weight. Imazamox, thifensulfuron, and bromoxynil caused minor visible injury of 8-12% and a reduction in dry weight of 17-27%. Pyrothiobac and chlorimuron caused 39 an 59% visible injury to guar, respectively, and a 42 and 63% reduction in guar dry weight, respectively. Lactofen caused 100% visible injury with 0 grams of viable above ground biomass recovered. Future research should evaluate guar tolerance to 2,4-DB, bentazon, imazethapyr, and possibly imazamox, thifensulfuron and bromoxynil in the field**.** Field trials studying guar control with lactofen in soybeans should also be initiated.

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INTERACTION BETWEEN GLYPHOSATE AND *BRADYRHIZOBIUM JAPONICUM* IN GLYPHOSATE RESISTANT SOYBEAN. Lori J. Abendroth, Roger W. Elmore, Fred W. Roeth, Lenis A. Nelson, Graduate Research Assistant, Professor, Professor, and Professor, Department of Agronomy and Horticulture, University of Nebraska, Lincoln, 68583; Loren J. Giesler, Professor, Department of Plant Pathology, University of Nebraska, Lincoln, 68583.

Glyphosate competitively inhibits 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), an enzyme which acts as a precursor to the synthesis of aromatic amino acids. Although glyphosate resistant (GR) soybean contains a resistant form of the enzyme, the bacteria which infect the roots, *Bradyrhizobium japonicum*, possess a sensitive form. After glyphosate application, the GR soybean translocates the chemical to metabolic sinks, which include young roots and nodules. Limited field research has been conducted concerning this interaction between *B. japonicum* and glyphosate. King, et al. (2001) found a negative trend in biomass and seed yield for GR soybean exposed to high glyphosate rates (1.12 lb ae/A) under a water-limited environment.

Field studies were designed using a randomized complete block design with four replications, at two locations (Clay Co. and Merrick Co.), with each location having non-irrigated and irrigated studies. Four varieties were included, ‘NC+ 2A82RR,’ ‘NC+ 3N31RR,’ ‘Hoegemeyer 270RR,’ and ‘Hoegemeyer 340RR.’ Three separate glyphosate rates and applications were used, with the control receiving no glyphosate. A “high stress” environment (similar to that used by King, et al.) was simulated for the second treatment, with glyphosate applied at .74 lb ae/A and 1.12 lb ae/A, at vegetative stage (V) of V1 and V4, respectively. A “normal” application was used as the third treatment with glyphosate applied at V4 and V9, with .74 lb ae/A used each time. Root nodulation and plant response was analyzed throughout the growing season with nodule counts, dryweight biomass, growth stage/height, and chlorophyll content collected at V1, V4, and V9. Yield data was collected for both locations.

Examining the Clay Co. irrigated site, treatments with inoculant showed a decrease in total nodulation during V4 for the high stress and normal treatments in ‘NC+ 3N31RR’ and ‘Hoegemeyer 340RR.’ Generally, no significant differences in total nodulation were present in V1 or V9 between the herbicide treatments. At V4, ‘NC+ 3N31RR’ had 26.3 nodules/plant (control) compared to 14.9 (high stress) and 14.1 (normal); with ‘Hoegemeyer 340RR’ following the same trend, 20.4 (control), 15.5 (high stress) and 16.0 (normal). Soybean yield was reduced in the normal treatment (3.65 Mg/ha) compared to the control (4.22 Mg/ha) for ‘Hoegemeyer 340RR.’

POTENTIAL HERBICIDE- FUNGICIDE INTERACTIONS IN SOYBEAN PRODUCTION SYSTEMS. Rebecca Bierman, Wayne Pedersen, Christy Sprague and Dean Riechers, Graduate Research Assistant, Associate Professor, Assistant Professor and Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Fungicide seed treatments are becoming increasingly popular for use with glyphosate- tolerant soybeans. A field study was conducted to determine whether particular combinations of fungicide seed treatments and POST- applied herbicides affect soybean yield. Thirty- six treatments were evaluated, involving six fungicide treatments [Rival, thiabendazole (TBZ), pentachloronitrobenzene (PCNB), captan, Maxim (fludioxonil) and a fungicide- free control] and six herbicides [imazethapyr, imazamox, glyphosate, glyphosate + imazethapyr, glyphosate + cloransulam-methyl and a hand-weeded control]. The study was repeated at three locations across Illinois during the summer of 2002.

Statistical analysis showed that herbicide- fungicide interaction significantly affected yield. However, neither herbicide nor fungicide were independently significant. The mechanism of the observed interaction is unclear. The results of this study do not support our original hypothesis, based on preliminary data, that the combination of Rival and imazethapyr is associated with decreased yields. It is possible that the observed yield effects may be due to fungicide treatments affecting plant health and, therefore, tolerance to herbicide stress. More research will be needed to further investigate this possibility.

WEED CONTROL IN FOOD GRADE SOYBEAN WITH INTER-SEEDED RYE. Bradley E. Fronning, Kurt D. Thelen, Dale R. Mutch, and Todd Martin, Graduate Research Assistant, Assistant Professor, District Extension Agent, and Technician, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Studies were conducted over three years (2000-02) at Kellogg Biological Station near Hickory Corners, MI to determine the effect of inter-seeded rye on weed and soybean biomass and soybean yield. Two experiments (drilled system, conventional system) were conducted which investigated soybean population, cultivation and inter-seeded rye. The drilled system had soybean planted in 19 cm rows at three populations with or without inter-seeded rye. Conventional system included soybean planted in 76 cm rows with or without inter-seeded rye and with or without cultivation.

Soybean biomass in the drilled system generally increased as soybean population increased and decreased in the presence of rye, as expected. Late season weed biomass decreased from 170 to 3 kg/ha^{-1} as soybean population increased from 446,000 to 1,333,600 plants/ha^{-1} in 2000. Late-season weed biomass decreased from 774 kg/ha^{-1} when no rye was present to 77 kg/ha^{-1} when rye was present in 2001. Soybean yield generally increased as soybean population increased, however, soybean yield was usually lower when rye was present than when rye was not.

Soybean biomass was lower when rye was present than when there was no rye in the conventional system. Late-season soybean biomass was higher when cultivated than when not cultivated. Rye alone, rye plus cultivation, and cultivation alone resulted in large reductions of late-season weed biomass compared to no rye plus no cultivation in 2001. When yield was averaged across main affects cultivation yielded more than no cultivation and no rye yielded more than with rye.

Spring planted inter-seeded rye may be a useful weed control tool for organic production agriculture. It has shown the ability to reduce weed biomass through out the growing season with out causing too much soybean yield reduction. When combined with cultivation inter-seeded rye may be more beneficial than when used alone.

MANAGEMENT OF COMMON WATERHEMP RESISTANT TO PROTOPORPHYRINOGEN OXIDASE (PPO)-INHIBITING HERBICIDES IN SOYBEAN. Hank J. Mager, Bryan G. Young, and Kassim Al-Khatib, Graduate Research Assistant and Assistant Professor, Southern Illinois University, Carbondale, Il 62901 and Associate Professor, Kansas State University, Manhattan, KS 66506.

Common waterhemp is a widespread problem in the Midwest and protoporphyrinogen oxidase-inhibiting herbicides have been frequently utilized for postemergent (POST) control of common waterhemp in conventional soybean. A common waterhemp population suspected to be resistant to PPO-inhibiting herbicides was identified in Madison County Illinois after repeated applications of diphenylether herbicides failed to control the common waterhemp in 2001. The site has a history of continuous soybean production and exclusive use of diphenylether herbicides for common waterhemp control. Common waterhemp seed was collected from this site and screened in the greenhouse for resistance to PPO-inhibiting herbicides. Lactofen at 420g ai/ha and acifluorfen at 840 g ai/ha controlled only 30 and 35%, respectively, of the Madison County common waterhemp population compared to 98% control of a population susceptible to PPO-inhibiting herbicides. Field studies were conducted in 2002 to evaluate the efficacy of several herbicides with different modes of action on the PPO-resistant common waterhemp and to evaluate herbicide strategies for management of PPO-resistant common waterhemp in soybean. Preemergence (PRE) applications of sulfentrazone, chlorimuron & sulfentrazone, s-metolachlor, s-metolachlor & metribuzin, alachlor, and flufenacet controlled greater than 96% of common waterhemp at 28 DAT. However, PRE applications of pendimethalin and flumioxazin controlled only 39 to 48% and 50 to 84% of common waterhemp at 28 days after treatment (DAT), respectively. Common waterhemp control 14 DAT was less than 30% from postemergence applications (5 to 20 cm common waterhemp) of the PPO-inhibiting herbicides lactofen, fomesafen, acifluorfen, flumiclorac, carfentrazone, flumioxazin, and sulfentrazone. No common waterhemp control was observed with imazamox suggesting that this population is also resistant to acetolactate synthase inhibiting herbicides. Glyphosate was the only POST herbicide labeled for use in soybean that provided acceptable control of this common waterhemp population. Treatments that included a soil residual herbicide followed by glyphosate POST controlled at least 97% of common waterhemp at 56 days after the POST application. Preemergence applications of pendimethalin or flumioxazin followed by a PPO herbicide provided less than 64% control 56 DAT. Results suggest the most effective management of PPO-resistant common waterhemp populations would include a non PPO-inhibiting soil residual herbicides followed by a POST application of glyphosate.

CONFIRMATION OF PPO-INHIBITOR RESISTANCE IN AN ILLINOIS WATERHEMP POPULATION. Aaron G. Hager, William L. Patzoldt, and Patrick J. Tranel, Assistant Professor, Graduate Research Assistant, and Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

A waterhemp population in western Illinois was not controlled following a postemergence application of lactofen in 2001. In 2002, field research was established at the location where the putative protoporphyrinogen oxidase (PPO)-resistant waterhemp population was discovered. The objective of these experiments was to determine the response of this waterhemp population to soil-applied and foliar-applied herbicides, including a variety of PPO-inhibiting herbicides and herbicides with other modes of action. Data collected 30 days after application of soil-applied herbicides revealed that all rates of sulfentrazone, flumioxazin, and fomesafen controlled waterhemp 86 percent or greater, suggesting this population was susceptible to these PPO-inhibiting herbicides applied to the soil. No soil-applied acetolactate synthase (ALS)-inhibiting herbicide provided control of this population, while control from herbicides with other modes of action was 81 percent or greater. Foliar-applied lactofen, fomesafen, acifluorfen, and carfentrazone provided between 13 and 46 percent control of waterhemp 21 days after application, comparable to the poor control reported by the grower following the lactofen application in 2001. Similar to the soil-applied experiment, no foliar-applied ALS-inhibiting herbicide controlled the waterhemp population. In contrast to the effective waterhemp control (81 percent) from soil-applied atrazine, foliar-applied atrazine provided only 14 percent control 21 days after application. Glyphosate was the only foliar-applied herbicide that effectively controlled this waterhemp population.

WEED CONTROL AND CROP SAFETY WITH GLYPHOSATE AND FOLIAR INSECTICIDES IN GLYPHOSATE RESISTANT SOYBEANS. Philip Boeve, Paul Ratliff, Troy Roebke, Rod Stevenson, Carl Urwin, and Greg Elmore, Monsanto Company, St. Louis, MO 63167.

Studies were conducted in 2002 to determine the compatibility of glyphosate tank mixed with seven commonly recommended foliar insecticides for bean leaf beetle and soybean aphid control in glyphosate-resistant soybean. Insecticides tested were carbaryl, chlorpyrifos, dimethoate, esfenvalerate, lambda-cyhalothrin, methyl-parathion, and zeta-cypermethrin. Weed control, crop response, and soybean yield were evaluated at six Midwest field locations and crop response was evaluated at a Monsanto Company greenhouse. No differences were found in common lambsquarters, giant foxtail, or velvetleaf control rated 21 DAT among the seven tank-mix combinations of glyphosate plus insecticide compared to glyphosate alone. Of the seven tank-mix combinations, only carbaryl and chlorpyrifos showed significant chlorosis and necrosis four DAT in the field and greenhouse studies and growth reduction 14 DAT compared with glyphosate alone in the greenhouse study. No yield reductions were found with the seven tank-mix combinations compared with glyphosate alone.

CHARACTERIZATION AND PERFORMANCE OF AN ALTERNATE SALT FORMULATION OF GLYPHOSATE IN MIDWESTERN ENVIRONMENT. Jeffrey B. Taylor*, Jeffrey A. Koscelny, Joseph J. Sandbrink, David C. Heering and Paul G. Ratliff, Technology Development Manager, Roundup Technical Manager, Roundup Technical Manager, Roundup Technical Manager, and Research Biologist, Monsanto Company, St. Louis, MO 63167.

The introduction of glyphosate-tolerant crops has led to the increased use of glyphosate herbicides for broad-spectrum weed control. In recent surveys, growers have indicated they have a need for continued innovation in glyphosate formulations. Growers continue to ask for complete formulations that are more concentrated and provide consistency of performance under a broad range of environmental conditions. In response to these needs, a new formulation of glyphosate has been developed. This new product is formulated as a potassium salt of glyphosate. Formulating glyphosate as a potassium salt offers various benefits such as higher glyphosate loading and lower viscosity, tangible benefits for the grower. Extensive research has been conducted in replicated greenhouse, growth chamber and field trials to evaluate the bioefficacy and glyphosate-tolerant crop safety of this new formulation. Bioefficacy has been evaluated in over 400 replicated field trials and over 50 replicated greenhouse/growth chamber trials. Applications made at labeled rates of this new glyphosate formulation provided excellent control (>90%) of the majority of weeds evaluated. Crop tolerance was also evaluated on glyphosate-tolerant canola, corn, cotton, soybeans and sugar beets at labeled and/or overlap rates. In addition to visual crop response evaluations, yield data was obtained for the majority of the trials. This new glyphosate formulation produced minimal or no affect on the foliage of the various crops tested and had no impact on yield.

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EFFICIENCY CRITERIA FOR ECONOMIC ANALYSIS OF WEED MANAGEMENT SYSTEMS.
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The objective of this research was to perform economic analyses of returns from several corn and soybean weed management trials in Minnesota. The specific economic analyses used in this research are designed to evaluate economic risk and find treatments that are efficient in reducing economic risk. Four separate trials for each crop were conducted at the Southern Research and Outreach Center near Waseca, MN. Weed species present at site 1 included: giant foxtail, common ragweed, common lambsquarters, and velvetleaf. Site 2 had common cocklebur. Site 3 had giant ragweed. Site 4 had tall waterhemp. Treatments costs were determined by summing the costs associated with herbicides and adjuvants, application costs, and cost of technology where applicable. Returns were calculated as the product of grain yield and commodity price minus treatment cost. Data for economic analysis were combined across each site. Efficiency criteria utilized in this research include then mean variance efficiency criteria, and both first- and second-degree stochastic dominance. Many treatments in both corn and soybeans provided adequate control of all weeds under investigation and resulted in economic returns that were not significantly different than the treatment with the highest returns. By using efficiency criteria, the list of preferred treatments can be further reduced to represent only those that are among the treatments both high in returns and risk efficient.

CONTROL STRATEGIES FOR COMMON DANDELION IN NO-TILLAGE SOYBEAN. 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.

Michigan soybean producers have reported an increase in the occurrence of common dandelion (*Taraxacum officinale*) in no-tillage, glyphosate-resistant soybean, especially when glyphosate is the primary herbicide. Two studies were established in fall 2001 to address this concern. An application timing study evaluated common dandelion control with glyphosate and 2,4-D ester as affected by application timing. Single applications of glyphosate + AMS, 2,4-D ester, and glyphosate + 2,4-D ester + AMS were applied at two timings in fall 2001 and two timings in the spring 2002. The second study evaluated common dandelion control with sequential applications of glyphosate following preplant applications of either glyphosate or 2,4-D ester. Both experiments were conducted at the Michigan State University Clarksville Experiment Station on established populations of common dandelion. Glyphosate-resistant soybean was planted into corn stubble in 19-cm row spacing.

To evaluate the effect of application timing, treatments were applied early fall (EFALL), late fall (LFALL), early spring (ESPRING), and late spring (LSPRING). Common dandelion control was evaluated at the time of soybean planting. Fall herbicide applications were more effective than spring applications. Glyphosate applied EFALL and LFALL at 843 g/ha provided 79 and 81 percent common dandelion control, respectively. Glyphosate applied ESPRING and LSPRNG provided 63 and 52 percent control, respectively. In general, common dandelion control with glyphosate was more effective than 2,4-D ester. 2,4-D ester at 562 g/ha applied EFALL, LFALL, ESPRING, and LSPRING provided 65, 74, 37, 34 percent control, respectively. Tank-mixing glyphosate at 422 g/ha + 2,4-D ester at 281 g/ha provided 72, 77, 50, and 34 percent control when applied EFALL, LFALL, ESPRING, and LSPRING, respectively.

Sequential applications of glyphosate significantly improved common dandelion control. Timing of the initial application is critical for common dandelion control late into the growing season. Initial applications of glyphosate and 2,4-D ester at 843 g/ha and 562 g/ha, respectively, were applied EFALL, LFALL, and ESPRING. A sequential application of glyphosate at 843 g/ha was applied at the V2 crop stage. Glyphosate applied EFALL and LFALL followed by the sequential application provided 84 and 83 percent control 54 days after planting, respectively. Glyphosate applied ESPRING followed by the sequential application provided 53 percent control. A single treatment with glyphosate applied only at the V2 timing provided 55 percent control, similar to the ESPRING followed by the sequential treatment. Applying 2,4-D ester EFALL and LFALL followed by glyphosate at the V2 timing provided 73 and 89 percent control, respectively. Common dandelion control with 2,4-D ester applied ESPRING followed by the sequential of glyphosate provided 62 percent control.

Glyphosate controlled common dandelion more effectively than 2,4-D ester. Either herbicide was more effective applied in the fall versus the spring. Tank-mixing glyphosate + 2,4-D ester controlled common dandelion greater than either of the herbicides alone when applied in the fall. When applied in the spring, the tank mixture was no more effective than the glyphosate alone. In addition, fall applications of glyphosate or 2,4-D ester followed by a sequential postemergence application was more effective than a spring application followed by the postemergence application. The ESPRING followed by the sequential treatment was no more effective than a single postemergence application at V2.

INFLUENCE OF SOIL APPLIED HERBICIDES ON WEED SPECTRUM AT POSTEMERGENCE TIMING IN SOYBEAN. Julie M. Young, Bryan G. Young, and Joseph L. Matthews, Researcher, Assistant Professor, and Researcher, Department of Plant, Soil, and General Agriculture, Southern Illinois University, Carbondale, IL 62901.

Field studies were conducted at one location in 2001 and two locations in 2002 to determine the influence of soil residual herbicides on the weed spectrum present at the time of postemergence (POST) glyphosate application in soybean and the subsequent effects on weed control with glyphosate and soybean yield. Herbicide treatments included 11 different soil applied herbicides or herbicide premixes applied at planting followed by glyphosate POST when weeds were 25 to 30 cm. Single and sequential applications of glyphosate were also evaluated. All soil applied herbicides except flumetsulam and cloransulam reduced giant foxtail density at the POST timing compared to the nontreated in 2001 and 2002. Giant foxtail density was reduced to the greatest extent by treatments that included s-metolachlor or flufenacet. Cloransulam, chlorimuron & sulfentrazone, flumetsulam, and metribuzin reduced common cocklebur density in both 2001 and 2002. Ivyleaf morningglory density was reduced by sulfentrazone, chlorimuron & sulfentrazone, flumioxazin, and cloransulam in both years. Giant ragweed density was reduced by cloransulam, flumioxazin, chlorimuron & sulfentrazone, and metribuzin in 2002. All soil applied herbicides reduced common waterhemp density in 2002 except flumetsulam and cloransulam. Common waterhemp density in cloransulam treated plots was 2 times greater than nontreated plots, most likely due to reduced soil shading and competition from giant ragweed. In 2001, giant ragweed, prickly sida, and yellow nutsedge densities were increased in pendimethalin treated plots compared to the nontreated. Giant foxtail, common cocklebur, and common waterhemp control 28 days after the POST application of glyphosate was not influenced by weed density at POST since control was at least 90% in all herbicide treated plots. However, giant ragweed and ivyleaf morningglory control 28 days after POST tended to be greater in plots with reduced densities of these weeds at POST. Soybean yield was greatest at all three locations in plots treated with cloransulam, chlorimuron & sulfentrazone, flumioxazin, flumetsulam or metribuzin. The results of these studies suggest that soil applied herbicide selection should be based on broadleaf weed spectrum with emphasis given to controlling the most competitive broadleaf weeds.

IMIDAZOLINONE-RESISTANT SUNFLOWER IN KANSAS. Phillip W. Stahlman, Patrick W. Geier, Gregory W. Kerr, and Troy M. Price, Professor, Assistant Scientist, Assistant Scientist, and Assistant Scientist, Kansas State University Agricultural Research Center, Hays KS 67601, and Northwest Research-Extension Center, Colby KS 67701.

Field experiments were conducted in 1999, 2001, and 2002 at Hay and in 2002 at Colby, Kansas to evaluate weed control and crop tolerance with imazamox-based treatments in imidazolinone-resistant sunflowers. Some experiments included an adjuvant comparison between methylated seed soil (MSO) and nonionic surfactant (NIS). In 1999, imazamox at 0.032 lb/A or higher plus NIS and UAN at 0.25% v/v and 2 qt/A, respectively, controlled tumble pigweed, redroot pigweed, and green foxtail by 100% at 26 DAT. Control of hophornbeam copperleaf increased from 82 to 92% as imazamox rate increased from 0.032 to 0.096 lb/A. All imazamox treatments caused 10% or less chlorosis at 6 DAT but plants recovered within a few days and seed yields were not affected. At 4 WAT in 2001, imazamox at 0.032 lb/A or higher plus MSO and UAN at 1% + 2.5% v/v controlled tumble pigweed as tall as 12 inches by 90% or more; however, control declined 15 to 25% within the next 2 wk. Conversely, puncturevine control at 4 WAT ranged from 45% to 85% with imazamox at 0.032 to 0.128 lb/A and increased to 85 to 100%, respectively, at 6 WAT. Leaf chlorosis at 6 DAT increased from 10 to 25% with increasing rate up to 0.128 lb/A. However, plants recovered completely within 3 wk and sunflower seed yields did not differ within or among growth stages. In 2002, tank mixing imazamox and imazapyr at 0.032 + 0.01 lb/A plus NIS at 0.25% and UAN at 1% v/v compared to imazamox + NIS + UAN enhanced control of redroot pigweed and puncturevine in one of two experiments, and Russian thistle, large crabgrass and prairie cupgrass in single experiments by as much as 56%; both treatments controlled tumble pigweed 100%. In two of three experiments, imazamox was more efficacious when applied with MSO than NIS, and both with UAN. Sunflower chlorosis also was greater with MSO, but injured plants in all experiments recovered completely within 3 wk.

TRIBENURON RATE AND TIMING EFFECTS ON WEED CONTROL IN SULFONYLUREA-TOLERANT SUNFLOWER. Curtis R. Thompson, Troy M. Price, Phillip W. Stahlman, and Alan J. Schlegel, Associate Professor, Assistant Scientist, Professor, and Professor, Southwest Research Extension Center, Northwest Research Extension Center, Agricultural Research Center-Hays, and Southwest Research Extension Center- Tribune, Kansas State University, 4500 E. Mary, Garden City, Kansas 67846.

Few herbicides are registered for use in sunflower and none are registered for postemergence control of broadleaf weeds. Objectives of these experiments were to evaluate tribenuron for broadleaf weed control in sunflower and to evaluate sulfonylurea (SU)-tolerant sunflower response to tribenuron.

SU-tolerant sunflower were planted at 25,000 seeds/a into silt loam soil at Colby Kansas on June 17 and at 14,000 seeds/a into silt loam soil at Tribune Kansas on May 29. Tribenuron was applied at 0.125, 0.188, 0.25, and 0.5 oz/a in combination with 1 oz quizalofop and 0.25% v/v NIS. Treatments were applied to sunflower at the 4-leaf, 8-leaf, 4 and 8-leaf, and bud growth stages. Treatments were applied with a tractor sprayer delivering 12 gpa at Colby and with a CO_2 backpack sprayer delivering 10 gpa at Tribune. Crop chlorosis and weed control were evaluated visually several times during the season. Only results of the 3 wk (Colby) and 5 wk (Tribune) evaluations following the bud stage treatment are reported. The experiment was a 4 by 4 factorial arrangement in a RCB design with 3 or 4 replicates.

No chlorosis or other crop injury was observed in the Colby experiment. Only slight (<5%) sunflower chlorosis was observed with bud stage treatments of tribenuron at 0.188, 0.25, or 0.5 oz/a in the Tribune experiment. No injury was observed from any other treatment. Observed tribenuron injury did not affect sunflower growth or development.

Tribenuron at 0.125 oz applied at the 4-leaf stage of sunflower at Tribune gave 70% Russian thistle control and 0.188 oz or less at the 4-leaf stage at Colby gave 60 to 80% control. All other treatments controlled Russian thistle 90% or greater. Kochia control was more variable and less than 80% at both locations. This in part could be due to partial populations of ALS-resistant kochia in the experiments. At Tribune, redroot and tumble pigweed were very rate responsive to tribenuron; highest control of each was with the 0.5 oz/a rate. Tribenuron at 0.5 oz/a also provided the highest tumble and redroot pigweed control in the Colby experiment, however, control was less rate responsive. Puncturevine was controlled 90% or greater with tribenuron at 0.5 oz at the 4-leaf stage of sunflower, tribenuron at 0.188 and 0.5 oz at the 8-leaf sunflower stage, or all treatments applied at the 4 + 8-leaf or bud stage of the sunflower.

Tribenuron will provide broad spectrum broadleaf weed control in SU-tolerant sunflower. However, limitations are ALS-resistant weeds and the risk of the ALS resistant gene escape into the wild sunflower 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 repeated in five locations across Nebraska to evaluate different brands of glyphosate herbicides after 2001 studies showed thereto be little or no differences in weed control of most species. The study was conducted in glyphosate tolerant soybean at Concord, and Lincoln, Nebraska. The study was conducted in glphosate tolerant corn in Clay Center. The study was conducted in wheat stubble in North Platte, Ogallala 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, Touchdown, Clearout 41 Plus, Glyfos Xtra, Roundup UltraDry and Roundup WeatherMAX. Most of the products represent the isopropylamine salt of glyphosate however, Touchdown is formulated as the diammonium salt of glyphosate, Roundup UltraDry is formulated as the mono-ammonium salt of glyphosate, Roundup WeatherMAX is formulated as potassium salt of glyphosate. In the wheat stubble at North Platte an additional treatment of Engame, a glyphosate acid, was included in the trial. All of the locations except Clay Center evaluated treatments at 15 and 30 days after treatment (DAT). Clay Center was evaluated at only 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 or Concord had any largely significant differences in control at the 0.42 or 0.84 kg ae/ha rates or at the 15 and the 30 DAT ratings. In Clay Center in the glyphosate tolerant corn there were little to no difference between any of the products at either the 15 or 30 DAT ratings with all brands providing over 95 percent control. At Sidney, in wheat stubble, there were once again very few significant differences between products at either rate. Touchdown provided less control than the other products however last year it provided better control than the other products. 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 Glyfos Xtra at the 0.42 kg ae/ha rate provided significantly less slimleaf lambsquarter control than the other products at 30 DAT. At 30 days after treatment Engame at 0.84 kg ae/ha provided significantly less weed control than the other products. In Ogallala, Engame provided significantly better weed control of yellow foxtail and kochia at both the 0.42 and 0.84 kg ae/ha rates than the other products.

As a whole, few differences were seen between different glyphosate brands in this study across the locations. However, with a difficult to control species and dry conditions some differences may be evident. Yet they do not appear with any consistency. Still with species that are easily susceptible to glyphosate there seems to be little or no differences rather rate, environmental factors, and most importantly costs will play a larger role than brand name in product selection.

COMPARISON OF GLYPHOSATE FORMULATIONS AND ADDITIVES FOR CONTROL OF SLIMLEAF LAMBSQUARTER. Robert N. Klein, Jeffrey A. Golus and Jim Daniel, Professor and Research Technologist, University of Nebraska, North Platte, NE 69101, and Product Development Manager, United Agri Products, Johnstown, CO 80534.

A study was conducted during the summer of 2002 to evaluate various glyphosate formulations and additives for control of slimleaf lambsquarter. The field was located near North Platte, NE on the West Central Research and Extension Center Dryland Farm. Seven treatments were laid out in randomized complete block design with three replications. 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 plot was located in winter wheat stubble, which was harvested on July 1. Treatments included two glyphosate formulations (1 = Roundup UltraMax, isopropylamine salt; 2 = Engame, monocarbamide dihydrogen sulfate acid) applied at three different rates (0.25, 0.5 and 0.75 lb ae/acre) with two additives (1 = Liberate - lecithin, methyl esters of fatty acids and alcohol ethoxylate; 2 = ammonium sulfate). Application date was July 19, 2002, with a temperature of 99 deg F. High temperatures for four days before and after application were: (July 15 to July 23) 91, 93, 97, 98, 99 - DOT, 102, 103, 94 and 89. Slimleaf lambsquarter at application was 6 to 12 inches tall, and under extreme stress due to the very hot and dry conditions. Plots were rated visually for percent control of slimleaf lambsquarter on August 11 and September 8. Glyphosate 1 plus additive 1 and 2 yielded 32, 53 and 82 percent control at the rates of 0.25, 0.5 and 0.75, respectively on September 8. Glyphosate 2 plus additive 1 resulted in 52, 97 and 100 percent control on the same date.

WINTER ANNUAL WEED INTERFERENCE IN SOFT RED WINTER WHEAT. Christopher M. Zwiener and Shawn P. Conley, Graduate Research Assistant and Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211.

Stand loss due to winterkill can be a serious problem for soft red winter wheat producers. Reduced stand often leads to growers questioning whether to establish another crop and concern over the impact on weed-crop interference. Therefore, research was conducted to quantify the effect of % stand loss and weed interference on soft red winter wheat yield. Field studies were conducted at two locations in Missouri with two winter wheat varieties. The experimental design was a randomized complete block, split-plot arrangement. The main plot affect was either weed-free or weedy plots. The sub-plot affect was % stand loss of 0, 20, 40, 60, 80, or 100%. Weed density and biomass were collected for winter annual and summer annual weeds. Winter annual weed density and biomass were taken at weed physiological maturity. Summer annual weed density and biomass were taken at wheat harvest. Winter wheat was harvested at physiological maturity and adjusted to 13% moisture. Percent stand loss affected test weight at both locations. At Columbia, yield decreased as stand loss increased. At Novelty, stand loss ≤ 40% did not affect yield. At Columbia, yield was reduced 38% in the weedy plots as compared to the weed-free treatments. Winter annual weed interference did not affect yield at Novelty. Results indicated that % stand loss decreased yield and that high density of winter annuals may decrease wheat yield.

GROWTH AND DEVELOPMENT OF WILD OAT. Krishona L. Martinson and Beverly R. Durgan, Graduate Research Assistant and Professor, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN. 55108, George O. Kegode, Assistant Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Wild Oat is an invasive and economically important weedy species in most cereal growing areas of the world, including the Red River Valley of Minnesota and North Dakota. Numerous research papers have focused on economic importance, geographic distribution, seedling dormancy and germination, population dynamics and wild oat response to herbicides. However, little research has focused on the biological aspect of growth and development or the difference in growth and development of early and late emerging wild oat plants. Differences in growth and development characteristics and environmental affects on wild oat growth and development are key pieces of information needed for optimum and consistent control. The objectives of this experiment are to evaluate the growth and development of wild oats, and determine if later emerging wild oat plants have a similar rate of growth compared to early emerging wild oat plants. Research plots were established at two locations in 2002; Fargo, North Dakota and Crookston, Minnesota to evaluate the growth and development of wild oat. Four emergence cohorts were selected; cohort 1 germinated in the initial week (one) of the experiment, cohort 2 in week two, cohort 3 in week three and cohort 4 in week four of the experiment. Plot size was 0.61 M x 0.61 M and the experimental design was a randomized complete block with six replications. In each emergence cohort, ten individual wild oat plants were randomly selected from the natural population and numbered. On a weekly basis, individual plants were evaluated for height, leaf number on main culm, number of tillers and total leaves. Date flag leaf emerged and date of heading were recorded. Two weeks after heading, individual plants were harvested and potential seed production was calculated. Soil temperature, air temperature (maximum and minimum) and rainfall were recorded on a daily basis. Data was analyzed and means were separated with a LSD of P = 0.05. All four cohorts appeared to have similar growth and development. Based on biomass, wild oats in cohort 1 were the largest and wild oats in cohort 4 were the smallest. Cohort 2 and 3 were not different from one another and were always larger than cohort 4. Cohort 1 had more potential seed production than the other three cohorts. Cohort 2 and 3 had less potential seed production than cohort 1 but more than cohort 4 and cohort 4 had the least amount of potential seed production. It appears that later emerging wild oat plants grew as faster, or faster, than earlier emerging wild oat plants, and cohorts 3 and 4 appear to have a shortened growing season. Wild oat plants in later emerging cohorts (3 and 4) also developed as soon, or sooner, than earlier emerging cohorts based on heading date. These results indicate that farmers must manage for all wild oats that emerge. Early emerging wild oat plants are larger and will be more competitive and will produce the most seed. However, later emerging plants, still have the potential to produce seed and if left uncontrolled, theses wild oat plants will continue to increase the seed bank.

MESOTRIONE USE IN OAT. Kirk A. Howatt and Eric E. Dvorak, Assistant Professor and Graduate Research Assistant, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Field experiments were conducted in 2002 at two locations to determine the response of oat to mesotrione. In preliminary greenhouse studies, 105 g/ha mesotrione with 1% v/v petroleum oil and 2.5% v/v urea ammonium nitrate adjuvants provided 85 to 90% yellow foxtail control while oat response was slight and temporary. Oat ‘Jerry’ was used in all field experiments. Mesotrione at 105 g/ha with adjuvants was applied to oat in seven growth stages from pre-emergence to 5-leaf stage. Injury, 4%, was most persistent when mesotrione was applied to 2- to 4-leaf oat. Mesotrione at 26, 52, 105, 210, and 420 g/ha with adjuvants was applied to oat. Initial injury 7 DAT with 26 to 210 g/ha mesotrione was 3 to 7%, while 420 g/ha mesotrione elicited 12% injury. Injury from all rates examined diminished to 1% or less 14 DAT. The addition of another broadleaf herbicide generally increased injury compared to 105 g/ha mesotrione with adjuvants or the other herbicide alone. Bromoxynil or bromoxynil and MCPA caused the greatest injury increase but did not reduce oat growth or yield. Mesotrione application timing or rate did not reduce oat reproductive tiller number, biomass accumulation, or grain production compared to untreated oat.

REDUCED HERBICIDE RATES FOR WILD OAT (*Avena fatua*) CONTROL: INFLUENCE OF TANK-MIX HERBICIDES. Brad K. Ramsdale, Sam J. Lockhart, and Calvin G. Messersmith, Research Fellow, Research Specialist, and Professor, North Dakota State University, Fargo, ND 58105.

Interference from wild oat causes significant yield reductions in North Dakota hard red spring wheat production. Previous research demonstrated that wild oat herbicide rates could be reduced by half when applied as split treatments (0.25X + 0.25X). Reduced grass control often occurs when graminicides are applied with broadleaf herbicides, especially at reduced graminicide rates. Therefore, field experiments were conducted near Fargo, ND, in 2001 and 2002 to evaluate the effect of tank-mixing broadleaf herbicides with reduced-rate split-applied treatments of CGA 184927 (proposed common name clodinafop), fenoxaprop-P plus safener, flucarbazone, and ICIA 0604 (proposed common name tralkoxydim) on wild oat control and wheat yield. Wild oat herbicides were applied once at 100% of the labeled wild oat rate to 3- to 4-leaf wild oat or split-applied as two 0.25X treatments totaling 50% of the full rate. Full rates were tralkoxydim at 2.8 oz ai/A, clodinafop at 0.8 oz ai/A, flucarbazone at 0.42 oz ai/A, and fenoxaprop-P at 1.32 oz ai/A. The first split treatments were applied to 1.5-leaf wild oat and the second to 4- to 5-leaf wild oat, which was 13 to 18 d after the first. Each wild oat herbicide was applied alone and with bromoxynil & MCPA ester at 4 oz ae/A, or fluroxypyr plus thifensulfuron at 1 plus 0.3 oz ai/A. Broadleaf herbicides were applied once with either the first or second split-applied treatments.

Wild oat control was 90% or greater when clodinafop, flucarbazone, tralkoxydim, and fenoxaprop-P were applied at the full-labeled-rate alone or with broadleaf herbicides. However, fenoxaprop-P as reduced-rate split-applied treatments provided 82% wild oat control, which was significantly less than fenoxaprop-P applied once at the full rate. When fenoxaprop-P was split-applied without broadleaf herbicides, wild oat control was less than with the other wild oat herbicides at 82%. Wild oat control was reduced when fenoxaprop-P was applied twice at reduced rates with bromoxynil and MCPA ester in the second application, indicating a slight antagonism. Wheat yields were similar among all treatments for each herbicide. These results indicate that wild oat herbicides can be applied as half-rate split-applied treatments plus a broadleaf herbicide and maintain effective weed control without loss of yield.

EVALUATION OF HERBICIDES FOR TRANSPLANTED PUMPKIN IN PLASTICULTURE.
John B. Masiunas, Associate Professor, Department of Natural Resources and Environmental Sciences, University of Illinois, Urbana, IL 61801.

Midwestern pumpkin growers are using transplants for cultivars with high-value hybrid seed and to ensure adequate stands. Plasticulture systems may allow growers to shorten cropping cycles while producing high quality fruit. In the southern portion of the region a shorter cropping cycle could allow growers to double crop pumpkins with an earlier crop such as cabbage, lettuce, or annual strawberries, spreading the input costs over multiple crops. Pumpkin tolerance to herbicides will differ in systems using transplants and plastic mulches. Also, many of the current PRE herbicides for pumpkins, such as clomazone and ethalfluralin, are volatile and can not be used under plastic mulch. The objective of the study was to evaluate the tolerance of transplanted pumpkins in plasticulture to herbicides applied between the plastic mulch. The experiment was a randomized complete block design with four replications. Beds were established and plastic laid on June 20. Herbicide treatments to bare ground between the plastic mulch were applied on June 28 using a CO_2 pressurized backpack sprayer fitted with 1.7 m wide hand-held boom that had four 8003 flat fan nozzle tips. The sprayer was calibrated to deliver 253 L/ha at 207 kPa. Six week old ‘Howden’ jack o-lantern transplants were planted between June 30 and July 2. Herbicide injury, pumpkin stand, and weed control were determined at two and four weeks after herbicide applications. The number of fruit, fruit weight, fruit quality, and storability were determined in late September. Combinations of clomazone plus ethalfluralin, halosulfuron, and isoflutole controlled common purslane, redroot pigweed, and velvetleaf. Neither clomazone, ethalfluralin, halosulfuron, nor isoxaflutole reduced the pumpkin stand, caused phytotoxicity or plant stunting. The herbicide treatments also did not reduce fruit number or weight. No herbicide treatment delayed maturity or effect fruit storability. In the plasticulture system, even with the late planting date and use of a later maturing cultivar, the fruit matured by late September and maintained their quality until well after Halloween.

2002 North Central Weed Science Society Abstracts 57:87.

WEED GERMINATION UNDERNEATH POLYETHYLENE FILMS WITH DIFFERENT OPTICAL PROPERTIES. Mathieu Ngouajio, Bernard H. Zandstra, and Jeremy, Assistant Professor, Professor, and Research Assistant, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Use of polyethylene film mulch is a simple and easy way to modify crop microclimate. Since the early 60's, use of plastic mulches for vegetable production has contributed enormously to reduce pesticides inputs in agriculture. Plastic film mulches provide non-chemical alternatives for control of insects, diseases, and weeds. Plastics chemistry has provided growers with films possessing a large variety of optical properties. Plastic mulch optical and physical properties affect its ability to transmit, reflect, or absorb light. These factors in turn affect the soil temperature as well as the quality and quantity of light prevailing under the plastic. The modified microclimate affects weed seed germination and development.

Laboratory and field experiments were conducted in 2001 and 2002 to (i) measure the optical properties of colored mulches, (ii) evaluate weed populations underneath each mulch type, and (iii) determine if film optical properties could be used to predict weed populations. Mulches used in the study included the following: white, black, coextruded white/black, gray, green infrared transmitting (IRT green), and brown infrared transmitting (IRT brown). Light transmission, reflection, and absorption in the 400 to 1100 nm range were measured using a LI-1800 spectroradiometer (LI-COR). In field experiments, density and dry biomass of weeds growing underneath the mulches were evaluated between 45 and 50 days after tomato planting.

The light transmitted through the mulches varied greatly. An average of 1, 2, 17, 26, 42, and 45 % light was transmitted through the black, white/black, gray, IRT brown, IRT green, and white mulches, respectively. Similar results were observed with light reflection. Reflected light was 8, 9, 10, 16, 25, and 51% for black, IRT brown, IRT green, gray, white/black, and white mulches, respectively. The white mulch absorbed minimal light (less than 2%). Light absorption by other mulches varied between 50 and 92%. Weed density and biomass were significantly different among the mulches ($P < 0.05$). The white mulch showed high weed pressure, followed by the gray mulch with moderate weed infestations. All other mulches provided an adequate level of weed suppression. Weed infestation was highly correlated with average light transmission for the white, black, white/black, and gray mulches. However, both light quantity and quality were necessary to predict weed infestations with the IRT mulches.

INULA BRITANNICA IN MICHIGAN NURSERIES AND POTENTIAL CONTROL METHODS.
Robert J. Richardson, Bernard H. Zandstra, Emily J. Carlson, and Thomas A. Dudek, Research Associate, Professor, Graduate Student, and Extension Agent, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Inula britannica L. is an invasive, perennial weed that has recently been introduced into several Michigan nurseries. *I. britannica* can produce large quantities of wind-disseminated seed and reproduce vegetatively from roots. Once introduced into nurseries, *I. britannica* forms dense colonies that are difficult to control. Field and greenhouse studies were conducted in 2002 to evaluate possible herbicidal control methods for *I. britannica* in cropping and non-crop situations. Studies conducted with *I. britannica* included glyphosate, glufosinate, clopyralid, dicamba, 2,4-D, triclopyr, diflufenzopyr, and other herbicides. In spring 2002 field studies, *I. britannica* control at 4 weeks after treatment (WAT) ranged 63 to 96% over clopyralid rates with or without adjuvant. Hosta was injured 22 to 45% and Astilbe was injured 11 to 22% from clopyralid. In fall 2002 field studies, *I. britannica* control was 95% or greater with 2,4-D, dicamba, clopyralid, clopyralid plus triclopyr, and glufosinate. Control was 78 to 82% with glyphosate and was only 47% with fluroxypyr. In greenhouse studies, 2,4-D, dicamba, dicamba plus diflufenzopyr, clopyralid, clopyralid plus MCPA, clopyralid plus triclopyr, and glufosinate controlled *I. britannica* at least 95% at 4 WAT. Hosta injury from herbicide treatments was generally lower in the greenhouse than the field, with the exceptions of clopyralid plus MCPA, clopyralid plus triclopyr, and glufosinate, which injured Hosta at least 82%. The addition of surfactant to clopyralid did not consistently affect weed control or crop injury in field or greenhouse studies.

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SENSITIVITY OF SEVERAL VEGETABLE CROPS TO ISOXAFLUTOLE SOIL RESIDUES.
Douglas Doohan, Joel Felix and David J. Lamore. Associate Professor and Research Associate, The Ohio State University, Wooster, OH 44691 and Technical Service Representative, Bayer Crop Science, Bryan, OH 43506.

'Pioneer 34B29 LL' was seeded at Fremont and at Wooster on May 22 and 24, 2001, respectively. Isoxaflutole was applied after seeding at 0, 53, 105 and 210 g/ha PRE. A blanket application of glufosinate was applied POST, once at Fremont and twice at Wooster. Weeds not controlled by herbicides were removed by hand. Grain corn yield was similar amongst all treatments. The sites were not fall-plowed but were disc harrowed to a depth of about 10 cm just before planting vegetables. Vegetables were seeded or transplanted within a 6 day period in late May 2002 in single row plots that were at right angles to the previous year isoxaflutole plots. Varieties used were 'Nantes' and 'Danvers 127' carrot, 'Striker' and 'Hialeah' snapbean, 'Red Dynasty' and 'Huron' cabbage, 'Peto 696' and 'Heinz 9437' tomato, and 'Aristotle' and 'Palidin' bell pepper. Pests, including weeds, were controlled with pesticides recommended by Ohio State University Extension. Weeds not controlled by herbicides were removed from the plots by hand. Vegetables were visually rated for crop injury at 2, 4 and 7 WAP, using the 0-100 linear scale. Vegetables were harvested repeatedly or 'once-over' depending upon the crop. All data were subjected to repeated measures ANOVA and the LSD (0.05) was used for mean separation. Interactions between variety and isoxaflutole rate were not detected; however, site was significant. At Fremont, onset of visible herbicide injury was detected earlier than at Wooster, and was generally more severe. Snapbean was the most sensitive crop, with injury 4 WAP ranging from <5% at Wooster to 40% at Fremont in plots treated the previous year with 53 g/ha isoxaflutole. At 7 WAP injury in plots treated with 105 g/ha was 10% at Wooster and 100% at Fremont. Snapbean yield at Wooster was not reduced relative to the untreated control (isoxaflutole 0 g/ha) with any rate of isoxaflutole but at Fremont yield was reduced in plots treated the previous year with 105 and 210 g/ha. Injury was typified on all crops by chlorosis starting with the oldest leaves and progressing to crop death in the extreme. Injury symptoms were also detected on cabbage and pepper at both sites. Injury at 53 g/ha was consistently 5% or less. Injury at 105 and 210 g/ha stabilized at about 10% for both crops at Wooster. Injury on cabbage and pepper was 20 and 15 % with 105 g/ha, and 25 and 18% with 210 g/ha, respectively, at Fremont. Yield was not reduced in either crop, regardless of rate or location. Tomato injury at 105 and 210 g/ha isoxaflutole was 13% or less at Fremont and 20% or less at Wooster, with no yield reduction. Carrot was not injured at either site. Greater sensitivity of vegetable crops to soil residues of isoxaflutole at Fremont may be related to drought conditions and a light corn crop in 2001.

WEED CONTROL IN CABBAGE WITH SULFENTRAZONE AND FLUMIOXAZIN. Richard G Greenland, Research Supervisor and Associate Agronomist, Oakes Irrigation Research Site, North Dakota State University, P.O. Box 531, Oakes, ND 58474.

Few herbicides are available for weed control in cabbage. We tested flumioxazin and sulfentrazone to determine suitability for cabbage production. These herbicides were applied to both direct seeded and transplanted cabbage.

For direct seeded 'Fresco' cabbage, flumioxazin injured cabbage when applied at 71 g/ha at either the 2 or 4-leaf stage. Weed control with sulfentrazone at 105 g/ha was fair to poor at either application time. All herbicide treatments resulted in lower cabbage yields than the hand weeded check.

In the transplanted 'Bronco' cabbage study, flumioxazin and sulfentrazone were applied at 71 and 105 g/ha, respectively, just before transplanting cabbage (PRE), 1 week after transplanting (1 WAT), or 2 weeks after transplanting (2 WAT). Except for flumioxazin applied PRE, these herbicides caused only minor injury to transplanted cabbage. Weed control was fair to good. Flumioxazin controlled common lambsquarters better when applied 2 WAT, and controlled hairy nightshade better when applied 1 WAT. The reverse was true for sulfentrazone control of common lambsquarters and hairy nightshade. Applying trifluralin preplant incorporated in addition to applying flumioxazin and sulfentrazone 2 WAT, increased weed control and improved yields compared to flumioxazin and sulfentrazone applied alone. Yields from all treatments were lower than the hand weeded check except for the trifluralin plus flumioxazin plus sulfentrazone treatment.

WEED CONTROL IN ORCHARDS USING PREEMERGENCE AND POSTEMERGENCE HERBICIDES. Michael G. Particka, Joseph G. Masabni, and Bernard H. Zandstra, Research Assistants and Professor, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Weed control is a crucial part of the overall management of an orchard. Weeds should be controlled to eliminate competition for nutrients and water, cover for deer and rodents, and alternate hosts for disease and insects. Weeds may cause poor crop pollination because weed flowers may be preferred by pollinators. Additional herbicides are needed to improve weed management in orchards because some of the current herbicides have a potential for leaching or weeds are becoming resistant. Herbicide trials were conducted at Michigan State University to compare new herbicides to herbicides currently used for weed control in apple and cherry. A preemergence application of glyphosate 1 lb ai/acre tank-mixed with azafenidin 1 lb or flumioxazin 0.375 or 0.75 lb provided good season long weed control. Sulfentrazone applied at 0.5 lb provided fair control of annual weeds but was weak on perennial weeds. A postemergence application of glyphosate 1 lb alone or tank-mixed with carfentrazone 0.02 lb provided good weed control. 2,4-D amine 1 lb, pyraflufen-ethyl 0.0088 lb, and 2,4-D acid 0.8 lb provided acceptable broadleaf weed control. Carfentrazone 0.02 lb alone provided unacceptable control of broadleaf weeds.

MANAGING WEEDS IN SWEET CORN WITH MESOTRIONE PROGRAMS. Douglas Doohan, Joel Felix and Dain Bruns. Associate Professor and Research Associate, The Ohio State University, Wooster, OH 44691 and Research and Development Scientist, Syngenta Crop Protection, Hilliard, OH 43026.

‘Attribute 0966’ was seeded May 10, 2002 and immediately treated with *s*-metolachlor PRE at 2.2 kg/ha. Two experiments were then established to evaluate weed control and sweet corn tolerance to mesotrione with different adjuvant systems, and with different rates and timing of the herbicide. The experimental design for both experiments was a randomized complete block with four replications. Mesotrione was applied in 233 L/ha at a pressure of 240 kPa. Weed control and crop injury were evaluated 2, 4 and 7 WAT. With mesotrione at 105 g/ha POST and single adjuvants, either AMS (1%), COC (1%), NIS(O.25%), or UAN (2.5%) slight chlorosis (3 % or less) was observed 2 WAT. Chlorosis increased to 4 and 6%, respectively with 2-way adjuvant systems of COC + UAN, and COC + AMS. Sweet corn sensitivity was dependent upon mesotrione rate, increasing from 3% chlorosis at 53 g/ha + COC POST to 9% and 13% as the herbicide rate was increased to 105 and 210 g/ha. Little or no chlorosis was observed when mestrione was applied PRE at rates from 176 to 423 g/ha; however, significant stunting (5-10%) was observed across the range. Crop yield was not affected by adjuvants. Weed control was significantly affected by adjuvant. Control of Canada thistle 2 WAT averaged 65% with mesotrione at 105 g/ha + AMS or COC or UAN and increased to 75 and 85%, respectively, with the same herbicide rate and COC + AMS, or COC + UAN. Canada thistle control was similar with mesotrione at 105 and 210 g/ha POST. However, the species was not adequately controlled with PRE treatments at rates from 176 to 423 g/ha. AMS + mesotrione at 105 g/ha POST provided 71 and 74% control of common- and giant ragweed, respectively. Control of these species was improved by approximately 25% when the herbicide was applied with COC or UAN. Control of common- and giant ragweed was similar with PRE or with POST mesotrione and control was not improved with 105 g/ha POST, relative to 53 g/ha POST. Differences in weed control at 2 WAT were still readily apparent at 7 WAT.

SWEET CORN CULTIVAR TOLERANCE TO MESOTRIONE. John Masiunas, Department of Natural Resources and Environmental Sciences, University of Illinois, Urbana, IL 61801, Christy Sprague, Department of Crop Sciences, University of Illinois, Urbana, IL 61801, Loyd Wax, United States Department of Agriculture, Agriculture Research Service, Urbana, IL 61801, and David Thomas, Syngenta, Champaign, IL 61821.

Weed control in sweet corn is problematic relying extensively on atrazine with few POST herbicide options. Atrazine use is being restricted in many sweet corn production areas because of concern about water contamination. Sweet corn cultivars also differ in tolerance to registered POST herbicides such as 2,4-D, dicamba, and nicosulfuron, limiting use of those herbicides. Mesotrione could provide an important replacement for atrazine and could fill some of the POST herbicide voids in sweet corn. The objective of our research was to determine if sweet corn and popcorn cultivars differed in their tolerance to PRE or POST applications of mesotrione. The experiment was a split plot design with four replications. The sweet corn or popcorn cultivars were the whole plot treatments and herbicides were the sub-plot treatments. Five sweet corn cultivars, 'GH 2547', 'GH 2684', 'GH 7749', Bonus, and 'Kandy Korn', and two popcorn cultivars, 'Weaver hybrid 1' and 'Weaver hybrid 2' were evaluated for their tolerance to mesotrione. Neither A12909 or A12854 applied PRE injured the sweet corn or popcorn compared to the atrazine and s-metolachlor control. One week after POST applications of mesotrione at 48 g/ha, the treatments with UAN caused more bleaching than the treatment with only COC. Mesotrione at 97 g/ha caused approximately 20% phytotoxicity on 'Bonus' and 'GH 2684'. Neither the other sweet corn cultivars ('GH 2547', 'GH 7749', and 'Kandy Korn') nor the popcorn cultivars were not significantly injured by mesotrione at 97 g/ha. By four weeks after treatment, all cultivars had recovered from injury and no treatment reduced corn height. Mesotrione did not reduce the number and weight of sweet corn or popcorn ears, thus not reducing yield. Ear quality (size, blanking, tip fill, husk cover) also was not effected by mesotrione. Thus, mesotrione has good safety on the sweet corn and popcorn cultivars included in this study.

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DEVELOPMENT OF A SWEET CORN COMPETITIVENESS INDEX. Sarah M. Kaping, Roger L. Becker, Vincent A. Fritz, James B. Hebel, Elizabeth J. Katovich, Undergraduate Research Assistant, Professor, Associate Professor, Research Coordinator and Senior Scientist, University of Minnesota, 411 Borlaug Hall, 1991 Upper Buford Circle, St. Paul, MN 55108.

Among sweet corn varieties there is a wide range of canopy architectures. Several studies have shown that the canopy shade of most crops greatly inhibits the growth of weeds due to lower light availability. Previous research has shown that sweet corn variety selection influences weed height, weed tiller number, weed biomass, light quality and light quantity. A field experiment was conducted to determine the light competitiveness of sixteen sweet corn varieties. PAR was measured and LAI was estimated. These light measurements aid in exploring the potential of selecting for crop canopy architecture to enhance competition with weeds. Differences were observed in canopy architecture among varieties. The results reflect the first year of this study and continuing research will be performed.

WEED DENSITY AND PERCENT COVER IN PUMPKIN FIELDS AND THEIR RELATIONSHIP TO CROP YIELD. Elizabeth T. Maynard, Regional Specialist, Department of Horticulture and Landscape Architecture, Purdue University, Westville, IN 46391.

Weedy and weed-free plots were established in nine commercial pumpkin (*Cucurbita pepo*) fields and one acorn squash field to evaluate broadleaf weed pressure and its relationship to crop yield during two growing seasons. One field from each of five farms was used in each season. Each producer applied his standard preemergent herbicide (clomazone and/or ethalfluralin) to all plots but subsequent cultivation and hand weeding were performed in the weed-free plots only. Grass weeds were removed from weedy plots by hand. Five to seven weeks after planting percent cover of broadleaf weeds in weedy plots averaged 12% (range 2% to 26%). Differences between farms were marginally significant at $P<.10$. Relative cover of broadleaf weeds, defined as (percent broadleaf cover)/(percent broadleaf cover+percent crop cover), averaged 0.22 in weedy plots (range 0.02 to 0.54). Relative cover differed among fields. The same two farms had the highest or next to highest percent cover and relative cover in both years; a third farm had the lowest or next to lowest percent and relative cover in both years. Percent cover estimates included pigweeds (*Amaranthus* spp.) on three farms in 1999 and two farms in 2000. Other weeds comprising more than 1/3 of the percent cover in at least one field included common ragweed, velvetleaf, horsenettle, carpetweed and ivyleaf morningglory. At harvest, densities of non-grass weeds averaged 10.5/m2 in weed-free plots and 17.0/m2 in weedy plots; total weed densities were 13.8/m2 and 19.5/m2, respectively. There was no difference in weed densities between weedy and weed-free plots averaged across all fields, but in some individual fields weed densities were higher in weedy plots. The most commonly recorded broadleaf weeds included common lambsquarters, pigweeds and velvetleaf. Weeds important in particular fields included horsenettle, eastern black nightshade, common ragweed, and yellow nutsedge. Aboveground weed dry weight at the end of the season was 15 g/m2 in weed-free plots and 151 g/m2 in weedy plots ($p< .001$). The weed treatment effect differed among farms: only three of the five farms had greater weed dry weight in weedy plots. Yields from pumpkin fields only were analyzed. Marketable yield averaged 31,800 kg/ha (range 11,400 to 54,200) with no difference between weedy and weed-free plots and significant differences between fields. Plants averaged 1 marketable fruit each (range 0.25 to 2.7), with an average weight of 5.2 kg (range 1.7 to 12.7), with no difference between weedy and weed-free plots but significant differences between fields. Relative yield, relative number of fruit per plant, and relative weight per fruit were defined as the value for a weedy plot expressed as a fraction of the value for the neighboring weed-free plot. Field means ranged from 0.69 to 1.56 for relative yield, 0.62 to 1.3 for relative number per plant, and 0.78 to 1.76 for relative weight per fruit. Linear relationships between field means for relative cover and relative yield or relative fruit number per plant explained 59% of the variation in relative yield ($P<.05$) and 66% of the variation in relative fruit number per plant ($P<.05$) when data from one field with carpetweed cover averaging 25% was excluded from analysis. Variation in relative fruit weight was not explained by relative cover. Linear relationships between non-grass weed densities at harvest and relative yield or relative number of fruit per plant explained 45% ($P<.05$) and 71% ($P<.01$) of the observed variation, respectively. Total weed densities explained similar amounts of variation. A linear relationship between the natural log of weed dry weight at harvest and natural log of relative yield explained 47% of the variation in relative yield ($P<.05$). Weed dry weight did not explain a significant amount of variation in relative fruit number per plant or relative fruit weight. The results suggest that in some fields weed control

measures in addition to preemergence herbicides are not necessary to prevent yield loss of pumpkins. With additional work, relative cover of broadleaf weeds might help to predict which fields are likely to benefit from postemergence broadleaf weed control measures.

WEED CONTROL IN TRANSPLANTED JUNEBERRY. Harlene M. Hatterman-Valenti, Assistant Professor, Plant Sciences Department, North Dakota State University, Fargo, ND 58105.

Few weed management options in juneberry or saskatoon (*Amelanchier* spp.) orchards have limited the potential for this new crop in North Dakota. Field trials have been initiated to evaluate the efficacy and crop safety associated with chemical and non-chemical weed control treatments. Non-chemical treatments consisted of strips of black fabric or black plastic, wood chips applied to a 10-cm depth, hand weeding (hoe), and an untreated. Chemical treatments consisted of two rates of azafenidin, flumioxazin, norflurazon, and oxyfluorfen, and one rate of oryzalin and trifluralin. Treatments were applied just prior to or immediately after transplanting. All plants were physically protected from herbicide spray contact when applications were made after transplanting. Black fabric, black plastic, hand hoeing, azafenidin, and flumioxazin provided season-long annual broadleaf and grass control at all locations. Oxyfluorfen provided season-long annual broadleaf and grass control in 2001 but not 2002. Perennial weed emergence and small animal digging opened the wood chip barrier allowing annual weed emergence in 2001 at one location. A consistent thick layer (10 to 14-cm depth) of wood chips in an area free from perennial weeds is needed for season-long weed control with this treatment. Crop health was difficult to assess. Visually evaluations indicated that azafenidin and flumioxazin injured juneberry during 2001. However, the percent of live plants in the treatments eight weeks after application were not different from the non-chemical treatments suggesting that other factors were involved in overall plant health. Further investigations under controlled environmental conditions are needed in order to determine crop safety with these herbicides and to assess plant needs for establishment.

EVALUATION OF ANNAGNPS 2001 FOR PREDICTING ATRAZINE LOADING. Troy J. Lively, Malcolm Levin, George Czapar, and Prasanta Kalita, Graduate Student and Professor, Department of Environmental Sciences, University of Illinois, Springfield, IL 62703, Adjunct Professor and Associate Professor University of Illinois, Urbana, IL.

Evaluation of the AnnAGNPS 2001 non-point water quality model was performed to determine its effectiveness for predicting atrazine loading in a small agricultural watershed in Springfield, Illinois. Data from four years of farm field and climatological sources were used in model calibration and validation with results compared to the corresponding four years of observed water quality data. Model prediction effectiveness was determined from two statistical methods: Root Mean Square Error (RMSE) and Model Efficiency (ME). Model predicted atrazine loadings per event were considerably different than those of the observed data even after the extensive calibration process performed prior to validation. RMSE and ME indicated a relatively high difference between atrazine loading prediction and actual observed values. The AnnAGNPS 2001 model did not meet expectations when considering atrazine loss/loading predictions and may not be appropriate when accurate quantities of atrazine loss and surface water runoff volume are needed.

PURPLE LOOSESTRIFE CONTROL WITH HERBICIDES: SINGLE YEAR APPLICATION . Stevan Z. Knezevic, Assistant Professor, Haskell Ag. Lab., University of Nebraska, Concord, NE, 68728-2828

The introduction and spread of exotic plant species is one of the most serious threats to biodiversity. Purple loosestrife (*Lythrum salicaria*) is one such species that is currently invading wetlands and waterways in mid-Western states including an estimated 12,000 acres in Nebraska. Once a wetland is taken over by loosestrife, the natural habitat is lost and the productivity of native plant and animal communities is severely reduced. Field studies were conducted in 2000 and 2001 at two locations in each year with the objective to evaluate performance of a single application of 14 herbicide treatments. Evaluation at 70 days after treatment (DAT) suggested that excellent season-long control (>90%) of purple loosestrife was achieved with glyphosate at 3.36 kg ae/ha; 2,4-D at 2.8kg ae/ha; triclopyr at 2.1kg ae/ha; imazapyr 1.68 kg ai/ha; and with the two mixtures of 2,4D+triclopyr at 1.4+1.26 kg ae/ha and 2,4-D+metsulfuron at 1.4ae/ha+0.044kg ai/ha. Evaluation at 365 DAT suggested excellent control (>90%) that can last more than one season was achieved only with imazapyr at 1.12 and 1.68 kg ai/ha and metsulfuron at 0.070 and 0.175kg ai/ha. The two imazapyr treatments however caused detrimental effects on the native vegetation indicating limited use of those treatments. Therefore, results of this study suggest that a single application of most of the tested herbicides did not provide satisfactory control of loosestrife that can last more than one season, indicating the need for multi-year applications.

SOIL MOISTURE AND THE SURVIVAL OF GARLIC MUSTARD SEEDLINGS. Richard D. Dirks* and Kevin D. Gibson, Graduate Student and Assistant Professor, Purdue University, West Lafayette, IN.

Garlic mustard, (*Alliaria petiolata)*, a non-native biennial herb that displaces native species, particularly spring ephemerals, has become widespread in eastern deciduous forests of the United States. Efforts to limit the spread of this invasive weed through conventional weed management practices have been largely unsuccessful. The development of alternative practices is clearly needed but will require a greater understanding of the processes and factors facilitating or limiting garlic mustard survival and dispersal. We assessed the relationship between abiotic factors and the survival of *A. petiolata* cohorts in pine and oak forests in Purdue University's Martel Forest in 2002.
Garlic mustard survival was generally lower for late emerging cohorts than for early emerging cohorts and ranged 31% to 57%. Garlic mustard had lower survival on warm dry soils than on cool wet soils. There was a significant negative relationship between average soil temperature and percent survival at the end of the season. Changes in soil water content and soil temperature during the season explained between 13% and 57% of the variation in cohort 1 survival. Our results suggest that garlic mustard survival may be closely linked to its ability to emerge early in the season and initiate growth during more favorable environmental conditions. Our results also suggest that xeric sites may be less susceptible to garlic mustard invasion than mesic sites. Additional research to determine the relationship between soil moisture and garlic mustard distribution and movement across the landscape should be evaluated.

MAPPING INVASIVE BUCKTHORN SPECIES IN THE NORTH CENTRAL REGION. Richard D. Dirks* and Kevin D. Gibson, Graduate Student and Assistant Professor, Purdue University, West Lafayette, IN.

Common buckthorn (*Rhamnus cathartica*) and glossy buckthorn (*R. frangula*) are non-native invasive shrubs that can form dense thickets in a variety of habitats. In addition to displacing native plant species, both species have been tentatively identified as overwinter hosts for the soybean aphid (*Aphis glycines*), an invasive pest of soybeans in the Midwest. It has been suggested that the spatial distribution of the soybean aphid may be related to the distribution of buckthorn species. While buckthorn species have been mapped in some states of the North Central region, relatively little is known about the spatial distribution of buckthorn species in Indiana, Iowa and Ohio. We conducted a survey of county extension agents, park superintendents, consulting and district foresters, herbarium curators and botanists in Indiana, Iowa and Ohio. Buckthorn species were identified in ten counties in Iowa, eight counties in Indiana and ten counties in Ohio. Response rates varied with state and occupation but were generally low. Maps compiled from our survey and other sources suggest that both species are widely distributed in the North Central region. However, ground surveys may be necessary to more accurately determine the spatial distribution of these invasive weeds.

SOIL FACTOR AND SPRAY TIMING EFFECTS ON SULFENTRAZONE PHYTOTOXICITY TO TWO SOYBEAN VARIETIES. Kristel L. Reiling, F. William Simmons and Dean E. Riechers, Graduate Research Assistant, Associate Professor and Assistant Professor, Department of Crop Science, University of Illinois, Urbana, IL 61801.

Sulfentrazone is a phenyl-triazolinone herbicide registered for preemergence use in soybean systems to control many small-seeded broadleaves and some grass species. Field experiments were conducted in 2001 and 2002 at three Illinois locations to: (1) evaluate what effect soil factors (pH and organic matter (O.M.)) have on sulfentrazone phytotoxicity to soybeans, and (2) determine the crop response of sulfentrazone application timings. Soil types at the three locations were a Flanagan silt loam with 3.6% O.M., a Drummer silt loam with 4.5% O.M., and a Cisne silt loam with 2.1% O.M. These studies were conducted on established pH plots where the pH was adjusted to 1 of 5 set target levels. The target pH levels were <6.0, 6.0-6.5, 6.5-7.0, 7.0-7.5, and >7.5. Sulfentrazone treatments consisted of 0.22 kg a.i. ha^{-1} (1X) and 0.44 kg a.i. ha^{-1} (2X) sprayed at three timings; 7-day early preplant (EPP), preemergence (PRE), and 50% soybean hypocotyl emergence (VE). Varieties ‘Pioneer 94B01’ (sulfentrazone sensitive) and ‘Pioneer 93B53’ (sulfentrazone tolerant) were used to evaluate crop response across all locations and years. Visual injury ratings were taken 14, 28, and 56 days after planting (DAP). Final stand counts were recorded in late spring and yield data was collected in the fall. At Brownstown, injury increased as soil pH increased for ‘Pioneer 94B01’ at the 1X VE treatment. Injury levels at the 2X EPP, 1X PRE, 2X PRE, and 1X VE application treatments were significantly higher than the injury levels at the 1X EPP treatment for ‘Pioneer 94B01’. ‘Pioneer 93B53’ injury was significantly higher at the 1X VE treatment compared to the 1X EPP treatment. Although significant injury levels were recorded, there were no differences in yield among the treatments for either variety. At DeKalb, injury levels increased as soil pH increased at the 1X VE treatment for both varieties. Injury levels were significantly higher at the PRE and VE application treatments for ‘Pioneer 94B01’. Injury levels were significantly higher at the 2X PRE treatment for ‘Pioneer 93B53’. There were no differences in yield among the treatments for ‘Pioneer 94B01’. For ‘Pioneer 93B53’, there was a significant yield decrease at the 1X VE treatment. At Urbana, ‘Pioneer 94B01’ injury levels increased with increasing soil pH at the 2X EPP and 2X PRE treatments. There was also a yield decrease as soil pH increased at the 2X EPP treatment for ‘Pioneer 93B53’. For ‘Pioneer 93B53’ there were no difference in injury levels among the application timing treatments. At the later treatments of 2X PRE and 1X VE, there was a significant increase in injury for ‘Pioneer 94B01’. Although there were significant differences in injury levels, there were no differences in yield. There was an increase in injury with increasing soil pH at all locations. Soil pH level accounted for 20-27% of the variability in soybean injury. Soybean injury ranging from 5-25% occurred at all locations, but yield was only reduced at Urbana at the 2X EPP treatment. In general, even the sulfentrazone sensitive soybeans did not suffer yield reductions even when early season injury symptoms occurred.

FALL-APPLIED AND PREPLANT HERBICIDES OF CONTROL OF HORSEWEED IN SOYBEAN. Geoffrey D. Trainer*, Mark M. Loux, and Anthony F. Dobbels, Graduate Research Assistant, Associate Professor, and Research Associate, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210.

Horseweed is an increasing problem in Ohio because of reduced tillage and the development of resistance to ALS-inhibiting herbicides. Field and greenhouse studies were conducted in 2001 and 2002 to determine: a) the effectiveness of herbicides applied in fall and spring for control of ALS-resistant horseweed in soybeans, and b) the response of 52 horseweed populations to foliar applications of cloransulam. In the first study, various preplant herbicides were applied with 2,4-D ester in November of 2001 or early April of 2002, when horseweed seedlings were less than 3 cm in diameter. When applied in the fall, imazaquin, sulfentrazone, metribuzin, flumioxazin, and flumetsulam controlled 73 to 80% of the horseweed 28 WAT, while control with glyphosate, chlorimuron plus sulfentrazone, or cloransulam did not exceed 65%. Early-spring application of chlorimuron plus sulfentrazone, sulfentrazone, flumioxazin, metribuzin, and imazaquin controlled greater than 90% of the horseweed 59 DAT, while control with glyphosate, flumetsulam, and cloransulam ranged from 83 to 89%. Fall application of metribuzin, imazaquin, and sulfentrazone resulted in horseweed population densities of 13 to 17 plants/m^2 28 WAT, but densities were 44 to 78 plants/m^2 for all other fall treatments. Early-spring application of chlorimuron plus sulfentrazone, flumioxazin, metribuzin, cloransulam, or sulfentrazone resulted in horseweed population densities of 0 to 5 plants/m^2, while densities for all other treatments ranged from 9 to 23 plants/m^2. In a second study, herbicides were applied in early May of 2002, when the horseweed was 7 to 15 cm tall. Treatments controlling at least 90% of the horseweed 30 DAT included glyphosate alone or in combination with 2,4-D or one of several preplant soybean herbicides, or a combination of 2,4-D plus metribuzin. In greenhouse studies, approximately 85% of the horseweed populations exhibited some degree of resistance to cloransulam. Response of the 52 populations to a foliar application of cloransulam at 52 g/ha was as follows: 0 to 20% control – 8 populations; 21 to 40% control – 21 populations; 41 to 60% control – 12 populations; 61 to 80% control – 3 populations; and 81 to 100% control – 8 populations.

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ANALYSIS OF SOYBEAN RESPONSE TO SIMULATED DRIFT RATES OF PGR HERBICIDES USING A FOLIAR RESIDUE TEST. Shane M. Andersen, Leon J. Wrage, Sharon A. Clay, Duane P. Matthees, Graduate Research Assistant and Professors, Department of Plant Science, South Dakota State University, Brookings, SD 57007.

Field studies were conducted to determine the effects of plant growth regulator (PGR) herbicides on soybean. Soybeans were treated at the V3-V4 growth stage with several rates of dicamba (diglycolamine salt) and 2, 4-D amine. Plants were harvested at 0, 6, 12, 24, and 48 days after treatment (DAT). Samples were analyzed for herbicide residue using an aqueous base foliage extraction method.

Applications of PGR herbicides to soybean caused easily identifiable symptoms. Increasing rates of each herbicide coincided with increased yield reduction. Chemical residue values diminished quickly after initial application. Residue values also had a strong negative correlation with yield.

TEMPERATURE EFFECTS ON BURNDOWN HERBICIDE EFFICACY. Ryan F. Hasty*, Christy L. Sprague, and Aaron G. Hager, Graduate Research Assistant, Assistant Professor, and Assistant Professor, University of Illinois, Urbana, IL 61801.

No-till soybean production has experienced considerable growth in recent years and researchers believe that winter annual weeds are becoming more prevalent due to a decrease in the use of residual herbicide. One of the problems with controlling existing vegetation in the spring is making applications in cool weather when weeds are not actively growing. A field experiment was established in Urbana in the spring of 2002 to address the following objectives: 1) determine the effect of air temperature during herbicide application on control of winter annual species, and 2) compare control of winter annual weed species from herbicides with differing speeds of activity. The trial was a randomized complete block design with six applications based on the daytime high air temperature ranging from 8 to 31 C. Herbicide treatments included glyphosate at 0.63 kg ae/ha, paraquat at 0.7 kg/ha, and paraquat plus metribuzin at 0.7 and 0.21 kg/ha respectively. Glyphosate or paraquat provided similar suppression of henbit when application temperatures were below 24 C. Tank-mixing metribuzin with paraquat improved henbit control at application temperatures of 24 C or less compared with paraquat alone. Henbit control from all treatments improved dramatically when application temperatures increased from 24 to 31 C, with paraquat or paraquat plus metribuzin providing significantly greater control than glyphosate. Overall, the effect of temperature was not significant for common chickweed control with glyphosate and paraquat plus metribuzin. However, temperature had a significant effect on paraquat for common chickweed, with common chickweed control increasing with increases in temperature. Similar to henbit control, glyphosate and paraquat were not significantly different when application temperatures ranged from 8 to 18 C with respect to henbit biomass. A dramatic decrease in henbit biomass was observed when glyphosate was applied at 31 C. Overall, paraquat plus metribuzin decreased henbit biomass as application temperatures increased. Across herbicides there were few differences in common chickweed biomass. However, at the 8 and 13 C application timings common chickweed biomass was significantly greater with paraquat compared with glyphosate or paraquat plus metribuzin. These results indicate that cooler temperatures had a significant impact on paraquat activity in controlling common chickweed, while glyphosate and paraquat plus metribuzin were not affected by temperature. Paraquat plus metribuzin provided the most consistent control of henbit and common chickweed across temperatures when comparing the total biomass of the plots. However, when the application temperature reached 31 C all herbicide treatments provided excellent control of these species. Total biomass in the glyphosate and paraquat plots was similar across all temperatures with the exception of 24 C. This indicates that there was very little difference between a contact and translocated, non-selective herbicide for control of these two species. Overall, increases in temperature at the different timings significantly enhanced weed control and reduced weed biomass.

MICRONUTRIENT LEVELS IN NORMAL AND GLYPHOSATE-RESISTANT SOYBEAN. Darrin M. Dodds, Don M. Huber and Michael V. Hickman, Graduate Research Assistant, Professor and Adjunct Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Previous research on a single variety has shown that foliar chlorosis from manganese deficiency may be exacerbated by the presence of glyphosate resistance genes. Studies were conducted with multiple varieties of conventional and glyphosate-resistant soybeans on two different soil types; a low manganese Sebewa loam at the Pinney Purdue Agricultural Center (PPAC) near Wanatah, IN and on a nutrient sufficient Chalmers silt loam at the Purdue Agriculture Research Center near West Lafayette, IN. Alachlor at 2.8 kg ai ha^{-1} and imazethapyr at 0.071 kg ai ha^{-1} was used for preemergence weed control at the ARC while clomazone at 1.12 kg ai ha^{-1} and imazaquin at 0.11 kg ai ha^{-1} was used at PPAC. Glyphosate was applied postemergence to the glyphosate-resistant soybeans at 1.12 kg ai ha^{-1} in order to determine the effect of postemergence glyphosate application on nutrient uptake and utilization. Twenty-five of the youngest, fully expanded leaves were taken from the center of each plot, air dried, ground through a 1 mm screen, and analyzed by ICP-AA analysis for tissue nutrient content. Tissue nutrient concentrations did not reflect differences in manganese deficiency symptoms at PPAC, possibly due to physiological efficiency or plant immobilization. At PPAC, intensity of manganese deficiency symptoms appeared to be variety specific. The genes that code for glyphosate resistance and postemergence applications of glyphosate appear to affect micronutrient uptake in some but not all soybean varieties. Tissue concentrations of nutrients and deficiency symptoms appear to be environment and variety specific.

EFFECT OF TIME OF DAY ON THE EFFICACY OF HERBICIDES IN SOYBEAN. Mark M. Loux, Geoffrey D. Trainer, and Anthony F. Dobbels, Associate Professor, Graduate Research Assistant, and Research Associate, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210.

Field studies were conducted in 2001 and 2002 to determine the effect of the time of day on the efficacy of foliar-applied herbicides in glyphosate-tolerant soybeans and in fallow areas following wheat harvest. In the first soybean study, conducted at South Charleston, OH in 2001 and 2002, and at Custar, OH in 2001, glyphosate, fomesafen, and cloransulam-methyl were applied postemergence in glyphosate-tolerant soybeans at 630, 350, and 13 g/ha, respectively. Treatments were applied at three-hour intervals from 6 am to midnight at South Charleston, and from 6 am to 9 pm at Custar. In the second study, conducted at South Charleston in 2002, treatments were applied at 6 am, noon, and 9 pm, and included the following: glyphosate at 420, 630, and 840 g/ha, three different glyphosate formulations at 840 g/ha, and mixtures of glyphosate at 840 g/ha with cloransulam at 7 and 13 g/ha.

The activity of cloransulam-methyl was not affected by time of application in 2001, but control of giant ragweed in 2002 was reduced by 15 to 20% at 6 and 9 am, compared to later applications. In 2001 at South Charleston, the activity of fomesafen on common ragweed was reduced at 6 am, 9 pm, and 12 am, compared to other applications. A similar trend occurred for giant ragweed at 6 and 12 am. In 2002, fomesafen activity on giant ragweed reached a maximum at 6 pm, and control was significantly reduced at 6, 9, and 12 am. In 2001, the activity of glyphosate on common ragweed was reduced at 6 am, 9 pm, and 12 am at South Charleston, and at 9 pm at Custar. Control of redroot pigweed was reduced at 6 and 12 am, and control of velvetleaf was reduced at 6 am. Control of giant ragweed was significantly reduced only at 6 am in 2002, but there was a trend for reduction in giant ragweed control in the early morning or late evening both years. In 2002, increasing the glyphosate rate from 420 to 840 g/ha improved giant ragweed control at noon and 9 pm, but did not improve control at 6 am. Three different glyphosate formulations were similarly affected by time of application. When glyphosate was applied with 13 g/ha of cloransulam-methyl, control of giant ragweed at 6 am improved from 58% to 78%, while control at noon and 9 pm was not affected and remained at 88 and 81%, respectively.

In the fallow study, treatments were applied at 6 am, 2 pm, and 9 pm, and included glyphosate at 840 and 170 g/ha, and a mixture of glyphosate and 2,4-D ester at 840 and 560 g/ha, respectively. Redroot pigweed, common lambsquarters, and common ragweed were 25 to 50 cm tall at time of treatment, and giant ragweed was up to twice this height. Time of herbicide application did not affect control of common lambsquarters, common ragweed, or redroot pigweed. Glyphosate was less active on giant ragweed when applied at 6 am or 9 pm, compared to 2 pm. The mixture of glyphosate plus 2,4-D controlled 100% of the giant ragweed regardless of time of application.

DRY BEAN RESPONSE TO FLUMIOXAZIN AND SULFENTRAZONE. Karen A. Renner and Gary E. Powell, Professor and Research Technician, Michigan State University, East Lansing, MI 48824.

Growers have few options for controlling eastern black nightshade (*Solanum ptycanthum* Dun.) and other broadleaf weeds that infest Michigan dry bean acres. Imazethapyr and imazamox control redroot pigweed (*Amaranthus retroflexus* L.) and eastern black nightshade and are registered for use in dry beans. However crop rotation to sugarbeets and cucumbers limits use of these herbicides the year prior to planting sugarbeets. Flumioxazin and sulfentrazone are registered for use in soybeans and provide good control of common lambsquarters (*Chenopodium album* L.), redroot pigweed, and eastern black nightshade. Therefore research was initiated in 2001 and repeated in 2002 to determine navy and black bean tolerance to preemergence applications of flumioxazin and sulfentrazone in Michigan. Flumioxazin at 54 g a.i./ha (2002 only), 70 g/ha, and 108 g/ha (2001 only) and sulfentrazone at 105 and 142 g a.i./ha were applied preemergence immediately after planting at the Saginaw and East Lansing sites in 2001 and 2002. 'Vista' navy bean was planted at the Saginaw site on June 13, 2001 and June 18, 2002. 'Jaguar' black bean was planted at the East Lansing site on June 11, 2001 and June 17, 2002. The soil type at Saginaw in 2001 was a silty clay with 3.1% organic matter and a soil pH of 7.8. In 2002, the soil type at Saginaw was a clay with 2.9% organic matter and a soil pH of 7.8. The soil type at East Lansing in 2001 was a sandy clay loam with 2.3% organic matter and a soil pH of 7.1. The soil type in 2002 at East Lansing was a clay loam with 3.4% organic matter and a soil pH of 6.9. Navy and black bean injury was evaluated 10 and 21 days after planting, and dry bean populations were counted 21 days after planting. Dry bean maturity was assessed in early September by comparing leaf yellowing in the weed-free control to leaf yellowing in the herbicide treatments. Dry beans were harvested for yield in late September; however yields are not reported here because plots were not maintained weed-free throughout the growing season.

Injury to navy and black beans from flumioxazin and sulfentrazone was dependent on rainfall in the 14 days following planting. In 2001 at East Lansing, 5.6 cm of rain fell in the 14 days after planting, and 3.1 cm of rain fell during that time period at Saginaw. In 2002, less than 0.2 cm of rain fell at East Lansing in the 14 days after planting, while 2.8 cm of rain fell at the Saginaw site. Flumioxazin did not injury navy beans in 2001 at the Saginaw site. However, sulfentrazone at 105 g/ha injured 'Vista' navy bean at the Saginaw site in both years and 'Jaguar' black bean at East Lansing in 2001. Navy and black bean populations were reduced by sulfentrazone in 1 of 2 years. Navy bean maturity was delayed in both years, while black bean maturity was not delayed. Flumioxazin at 54 g/ha injured 'Vista' navy bean at the Saginaw site in 2002 and reduced navy bean populations by 30%. Flumioxazin at 70 g/ha injured 'Jaguar' black bean and reduced bean populations by 40% at the East Lansing site in 2001. Navy and black bean maturity was not delayed. Injury to these two dry bean classes from flumioxazin and sulfentrazone would not be acceptable to dry bean growers.

AGRONOMIC BENEFITS OF MANAGING WINTER ANNUAL WEEDS WITH FALL APPLICATIONS OF CHLORIMURON ETHYL + SULFENTRAZONE MIXTURES. Marsha J. Martin, Helen A. Flanigan, Kevin L. Hahn, and David W. Saunders, Development Representatives and Product Development Manager, DuPont Crop Protection, Johnston, IA 50131

Field studies were conducted between October, 2000 and June, 2002 to compare burndown and residual activity of fall application of chlorimuron ethyl + sulfentrazone mixtures against other herbicides labeled for fall application ahead of soybean planting. Tests were conducted in Indiana, Illinois, Michigan, Missouri, North Carolina, Ohio, Pennsylvania, and Wisconsin on winter annuals, early-emerging summer annuals, and certain perennials. For broad-spectrum burndown and residual control, chlorimuron ethyl + sulfentrazone + tribenuron ethyl mixtures performed the best, with glyphosate and glyphosate + imazaquin mixtures performing well for burndown of diverse weeds but losing control in May due to new germination and lack of significant residual.

Soil temperatures, taken at 4 inch depth in fields with fall-applied chlorimuron ethyl + sulfentrazone + tribenuron ethyl mixtures, averaged 5.5 Fahrenheit degrees warmer in mid-April and 3.5 Fahrnheit degrees warmer in mid-May than soil temperatures taken at 4 inch depth in side by side spring glyphosate burndown treatments. At one location in Amboy, Indiana, where soil temperatures were taken biweekly between April 9 and May 24, 2002, soil treated with Fall applications of chlorimuron ethyl + sulfentrazone + tribenuron ethyl mixtures averaged 3 Fahrenheit degrees warmer than the side by side spring glyphosate burndown treatment.

In 2002, yields were taken at seven Indiana and Ohio test locations. Treatments with fall applications of chlorimuron ethyl + sulfentrazone + tribenuron ethyl mixtures averaged 105.9% of the side by side spring glyphosate burndown treatments.

FALL-APPLIED HERBICIDE EFFICACY ON SUMMER ANNUAL WEEDS IN NO-TILL SOYBEAN. Chad D. Lee, Mark M. Loux, and Karen A. Renner. Assistant Professor, Department of Agronomy, University of Kentucky, Lexington, KY 40546-0091, Associate Professor, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210, and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing MI 48824.

Research was conducted in 2001 and 2002 in Ohio and Michigan comparing the efficacy of fall, early spring and 7 d pre-plant herbicide applications. Herbicide programs 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}. Winter and summer annual weeds that were not controlled by the fall, early spring, or 7 d pre-plant programs remained in the soybeans until the R1 growth stage at which time glyphosate at 841 g ae ha^{-1} was applied. Weed control ratings were taken 28 d after planting and at R1 soybean stage. Fall applications containing chlorimuron ethyl controlled common lambsquarters and common ragweed. All fall applications provided less than 90% control of annual grasses and giant ragweed. Early spring and 7 d pre-plant applications of the chlorimuron programs, metribuzin + flumetsulam, glyphosate + imazaquin and glyphosate + imazethapyr controlled common lambsquarters in Michigan in 2001 and 2002. Those same programs applied in early spring or 7 d pre-plant controlled common ragweed in Michigan in 2002. No differences in yield resulting from fall herbicide programs were observed in Ohio. Soybean yields were greater with fall applications containing chlorimuron ethyl or imazaquin in Michigan in 2002 and glyphosate + 2,4-D in 2001 compared with other fall applications. No fall herbicide applications controlled all summer annual weeds. Annual grass and giant ragweed populations would increase over time if weed management was based solely on fall applications since no fall program controlled these species. In general, most herbicide programs applied in the spring provided better control of summer annuals than herbicide programs applied in the fall.

VEGATATIVE PROPAGATION OF COMMON WATERHEMP. Christopher L. Schuster and Reid J. Smeda, Graduate Research Assistant and Assistant Professor, Agronomy Department, University of Missouri, Columbia, MO 65211.

Common waterhemp, a dioecious plant, exhibits broad genetic diversity. Identification of herbicide resistance in a mixed population of resistant and susceptible plants may not be possible without several generations of selection for resistant only plants. Identification of specific resistant plants and asexual propagation of those plants may permit studies to determine the extent and basis for resistance. Experiments were conducted in a controlled environment to determine an optimal procedure to asexually propagate common waterhemp. Shoot cuttings were taken from the tips of vegetatively mature common waterhemp plants. Vegetative propagation of plants was accomplished by water-based culture (hydroponics), mist chamber with plants rooted in vermiculite, and traditional transplanting methods (shoot cuttings placed in soil). The hydroponics methods of propagation included solutions of softened tap-water and of a nutrient enriched Hoagland's solution placed in black polypropylene containers. The bottom 4 cm of shoot cuttings was immersed in solution. The container was aerated by use of an aquatic pump. Mist chamber methods consisted of polypropylene trays containing vermiculite, placed into a mist chamber with a misting frequency of 30 seconds every 12 minutes. Shoot cuttings were placed upright in the vermiculite trays, with the bottom 5 cm covered. Prior to placement in the vermiculite trays, half of the shoot cuttings were dipped into a rooting hormone powder, Rootone®. The four methods of propagation were compared to a control, in which cuttings were placed directly into an artificial soil. Treatments were harvested at 4, 8, 12, 14, and 16 days after propagation, with root length, root weight, shoot length, and shoot weight recorded. At each harvest date three plants from each treatment were also placed into an artificial soil for 2 weeks to determine transplant efficiency. The emergence of shoot-borne roots was first recorded on day 8 for cuttings placed into the hydroponics solutions or mist chamber, and on day 12 for the shoot cuttings propagated in artificial soil. Root formation occurred around the circumference of the stem, and along the interveining length of the first internode. By day 16, root growth in Hoagland's solution was 5 to 9-fold greater than cuttings propagated by other methods. The cuttings propagated in Hoagland's solution obtained 32, 87, and >89% more shoot weight gain than other treatments at days 12, 14, and 16, respectively, in the transplant efficiency study. Entire plants can be obtained within 8 days of propagating shoot cuttings in water culture. These results indicate that the optimal procedure to propagate waterhemp cuttings is to use a water culture technique with a Hoagland's solution.

EFFECTS OF IRRIGATION AND CROP CANOPY ON EMERGENCE AND REPRODUCTIVE DEVELOPMENT OF VELVETLEAF. Kerry E. Cluney, John Cardina and Douglas Doohan, Graduate Research Assistant and Associate Professors, Department of Horticulture and Crop Science, The Ohio State University, Ohio Agricultural Research and Development Center, Wooster, OH 44691.

Two of the most effective ways to minimize crop losses due to weed competition are to control weed emergence during the critical period of crop canopy formation and to delay or disrupt seed production in order to minimize the amount of seed released into the seedbank. A study was conducted in 2001 and 2002 to examine the effects of irrigation and soybean canopy on the emergence pattern and rate of reproductive development of velvetleaf (*Abutilon theophrasti* Medic.). ANOVA and non-linear regressions indicated that irrigation and crop did not affect velvetleaf emergence patterns. Due to adequate rainfall and little crop competition early in the season, differences in soil moisture and soybean canopy did not appear until most emergence had ceased. Velvetleaf plants emerging on different dates were monitored weekly and scored according to the first observation of four reproductive stages: bud, flower, pod and mature pod. A maturity index was used to measure the rate at which plants growing in different irrigation and crop regimes reach reproductive maturity. Crop had a greater impact on the rate of velvetleaf reproductive development than irrigation. Crop competition increased time to maturation but velvetleaf emerging before June were still capable of producing mature seed.

RETROSPECTIVE PERTURBATION ANALYSIS OF CROPPING SYSTEM EFFECTS ON GIANT FOXTAIL DEMOGRAPHY. Adam S. Davis, Philip M. Dixon and Matt Liebman, Graduate Research Assistant, Department of Agronomy, Professor, Department of Statistics, and Professor, Department of Agronomy, Iowa State University, Ames, IA 50011.

Most agricultural systems are designed without regard to their intrinsic effects upon weed populations. Yet cropping system characteristics may affect weed population dynamics by altering key demographic rates of weeds. We examined the effects of legume green manure and tillage timing upon giant foxtail (*Setaria faberi*) demography using retrospective perturbation analysis of a periodic matrix population model. Retrospective perturbation analysis is used to estimate the contribution of treatment effects on a given demographic rate to overall treatment differences in population growth rate (λ). In this method, observed variation in a given demographic rate is weighted by the sensitivity of λ to changes in that demographic rate. Demographic data were collected for giant foxtail grown in a wheat-corn-soybean crop sequence in the central USA in 2000 and 2001, with either a wheat sole-crop ('W') or wheat/red clover crop mixture ('R') in the wheat phase. Residues from the wheat phase were incorporated either in fall ('FT') or spring ('ST') for a factorial of four cropping system treatments: FT/W, FT/R, ST/W, and ST/R. Demographic rates estimated from the field data included seed survival from October to March ($\sigma_{s(w)}$) and March to October ($\sigma_{s(s)}$), seedling recruitment (γ), plant survival (σ_p), fecundity (ϕ) and proportion of newly dispersed seeds not consumed by seed predators ($\sigma_{s(pred)}$). Deterministic simulations of giant foxtail population growth indicated that there were both interannual and management-induced variations in λ. The FT/R treatment had consistently low values of λ compared to the other cropping system treatments. Retrospective perturbation analysis suggested that $\sigma_{s(w)}$, ϕ, and $\sigma_{s(pred)}$ were important driving variables for this system. There was more variation in ϕ and $\sigma_{s(pred)}$ in response to changing management treatments than for $\sigma_{s(w)}$, leading to greater contributions from ϕ and $\sigma_{s(pred)}$ to differences in λ between the various management treatments than from $\sigma_{s(w)}$. Retrospective perturbation analysis of matrix population models has the potential to aid the design of integrated weed management systems by elucidating cropping system effects upon weed demography.

RELATIVE COMPETITIVENESS OF SHATTERCANE AND COMMON SUNFLOWER BASED ON EARLY SEASON GROWTH AND DEVELOPMENT. Eric L. Blinka and J. Anita Dille, Graduate Research Assistant and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66502.

The relative competitiveness of plants can be examined through growth analysis. Relative growth rate (RGR), leaf area ratio (LAR), and the net assimilation rate (NAR) are just a few of the parameters used to describe growth analysis. It is expected that all three of these parameters would decrease over time due to the production of less photosynthetically active plant material such as stem tissue and shaded leaves. Our objective in this experiment is to determine the early season relative competitiveness of shattecane and common sunflower in corn through growth analysis under different competition scenarios. Plots were established with different weed mixture combinations. Destructive harvests were performed periodically to determine plant leaf area and above ground biomass. This information was then sent through a growth analysis computer program that derived the best fit models, means, and standard errors for the plant growth parameters RGR, LAR, and NAR. The findings suggested that when shattercane and common sunflowers were grown together by themselves, shattercane was more competitive. However, when shattercane and common sunflower were grown together in the presence of corn, common sunflower became more competitive.

EMERGENCE DATE AFFECTS GROWTH AND FECUNDITY OF REDROOT PIGWEED.
Ebandro Uscanga-Mortera, Frank Forcella, and Jeff Gunsolus, Graduate Research Assistant, Research Agronomist, and Professor, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul 55108; USDA-ARS, Morris, MN 56267; and CONACyT and Colegio de Postgraduados, Mexico.

New cropping systems such as minimum tillage coupled with the use of Roundup-Ready cultivars, has created a favorable environment for success of redroot pigweed (*Amaranthus retroflexus*). This species sometimes escapes control because of delayed seedling emergence. Our objectives were to determine (a) the effect of simulated emergence date (transplanting date) on seed production of redroot pigweed that potentially could escape control under the Roundup-Ready system, and (b) the effect of soybean and corn competition on the growth and seed production of redroot pigweed "emerging" at different times. Seedlings emerging in greenhouse conditions were placed both outside (monoculture) and inside of soybean and corn plots on June 4th, and 18th, July 2nd and 16th in both 2001 and 2002 in western Minnesota. Seedlings were placed in the middle two crop rows (76 cm wide), spaced 25 cm apart, and monitored periodically for several gross morphological characteristics that might be associated with fecundity. Plant dry weight and seed production was determined at the end of the growing season. Seed production of redroot pigweed was not affected significantly by emergence date for plants in monoculture, but it was affected significantly by emergence date for plants growing in association with crops. Plants emerging late produced fewer seeds than plants emerging early. Redroot pigweed plants growing in association with either soybean or corn produced almost no seeds if they emerged >28 days after crop emergence. However, for plants emerging 0 through 14 days after the crop, those growing in soybean produced about twice as many seeds as those growing in corn.

COMPETITIVENESS OF SELECTED WEED SPECIES IN SOYBEAN. Shawn M Hock*, Stevan Z. Knezevic, Alex R. Martin, John L. Lindquist. Graduate Research Assistant, Professor, Professor, Professor. University of Nebraska. Department of Agronomy and Horticulture 279 Plant Science P.O. Box 830915 Lincoln, NE 68583-0915.

A competitive species is the one that can out-compete it's neighbor for nutrients, water, and light. Weed competitiveness can be quantified utilizing the concept of competitive index (CI). Weed competitiveness is affected by environmental conditions. Therefore, the CI of each weed species may very depending on environmental conditions. This study was conducted to determine and compare CI values among weed species as influenced by crop row spacing, and relative time of emergence. Field studies were conducted at 2 locations in eastern Nebraska in 2002. Glyphosate resistant soybeans were planted in 19 cm and 76 cm row spacing. A total of 12 species (velvetleaf, common lambsquarters, redroot pigweed, common waterhemp, common sunflower, common cocklebur, pennsylvania smartweed, giant ragweed, yellow foxtail, green foxtail, fall panicum, and barnyardgrass) were planted at soybean planting (VP), emergence (VE), and 1st trifoliate (V2). Weeds emerged at cotyledonary (VC) and first nodal (V1) stages of soybean. Competitive indices were affected by row spacing. CI's varied depending upon the quantifier (e.g. total dry matter (TDM), volume, and WeedSOFT NE). CI's based on TDM matched more closely to the CI's in WeedSOFT than the volume based CI's. The most competitive species were common sunflower and giant ragweed; the least competitive species were fall panicum and yellow foxtail. Narrow row spacing reduced TDM in most species, however, the most competitive species, common sunflower and giant ragweed, accumulated more dry matter by season end in narrow row spaced soybean.

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. In 2001 each plant received one of three nitrogen treatments: 0, 1 g, or 3 g of nitrogen applied as ammonium nitrate. In 2002 each plant received 0, 2, or 6 g of nitrogen. Measurements of total above and belowground biomass were made at 10 different sample dates 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.

GROWTH ANALYSIS OF LANCELEAF SAGE IN FOUR DIFFERENT NORTH DAKOTA SOILS. Mathew G. Carlson and Kirk A. Howatt, Graduate Research Assistant and Assistant Professor, North Dakota State University, Fargo, ND 58105.

Abstract. Lanceleaf sage is an annual broadleaf found throughout the central United States and has slowly moved throughout North Dakota. Greenhouse studies were conducted to evaluate growth rates of lanceleaf sage (*Salvia reflexa* Hornem.) in four different North Dakota soils to determine whether soil texture influenced severity of lanceleaf sage in North Dakota. Experimental design was a split-plot design with six replicates. Week was whole plot, and soil was subplot. Soil textures were loamy sand, silt loam, sandy loam, and silty clay. Lanceleaf sage seeds were planted in non-drainable pots. Soil was watered to fifty-percent field capacity daily. Nitrogen and phosphorus were applied to soil weekly based on initial soil nutrient tests. Nitrogen and phosphorus were applied at different rates to soil since soil nutrients varied in each soil. Plants were evaluated for height, width, leaf area, root volume, and root weight. Lanceleaf sage plants when grown in different soils had similar growth in height and width early in the growing season. Plant height increased rapidly to week five and then slowed for the next three weeks. Plants in silt loam and sandy loam were taller than plants grown in loamy sand and silty clay soils. Lanceleaf sage grown in sandy loam had the largest width for most of the study. Plant widths in silt loam, sandy loam, and silty clay soils were similar. Lanceleaf sage in sandy loam had the largest leaf area for most of the study, while plants in silty clay and loamy sand soils had the lowest leaf area for most of the study. Courser textured loamy sand and sandy loam soils produced plants with the largest root weight for most of the study. Finer textured silty clay loam and silt soils restricted root growth compared to courser textured loamy sand and sandy loam.

EFFECT OF LIGHT AND TEMPERATURE INTERACTIONS ON WEED SEED DORMANCY. Ramon G. Leon-Gonzalez* and Micheal D. K. Owen, Graduate Research Assistant and Professor, Iowa State University, Ames, IA, 50011.

Seed dormancy is one of the most important characteristics of weeds and extends the germination and emergence of weeds over time thus favoring the persistence of seeds in the seed bank. Knowledge about dormancy regulation is very important not only in understanding the biology of a plant species, but also the success of that species as a weed in an agroecosystem. In general, the regulation of dormancy level is exerted by physiological changes in the seed that are environmental dependent and independent. Temperature and light are two key environmental factors that impact the dormancy level of several species.

The effects of temperature and light and their interaction on the dormancy of common waterhemp, giant foxtail and velvetleaf seeds were studied under controlled growth chamber conditions. Seeds were either chilled (wet conditions at 4 C for 12 wk) or maintained in dry storage. Then, seeds were germinated under increasing and decreasing temperatures, and under continuous red light (R) and far-red light (FR). In addition, chilled and non-chilled seeds were germinated in the dark after being exposed to alternating R and FR flashes.

Velvetleaf seeds germinated between 12 and 36 C. The germination of this species was increased by exposure to high temperature immediately following exposure to low temperature, but light had no effect. Chilling did not affect velvetleaf dormancy. Giant foxtail showed clear interactions between light and chilling and temperature and light. Giant foxtail germination occurred between 20 and 28 C. Temperatures higher than 30 C were inhibitory. Heat shock after cold storage reduced the dormancy level of this species more than a gradual increase in temperature. Continuous exposure to FR reduced the germination of chilled giant foxtail seeds only under increasing temperatures. Thus, giant foxtail seed dormancy was, to some extent, phytochrome regulated, but high temperature exerted a more important regulation. In the case of common waterhemp, interactions between chilling, light and temperature during germination were observed. Common waterhemp seeds germinated between 16 and 36 C. Chilling reduced common waterhemp seed dormancy and increased sensitivity to light and temperature. When exposed to increasing temperatures, chilled seeds under R germinated at lower temperatures than the other treatments. R promoted germination, whereas FR inhibited germination and maintained dormancy. In addition, the effect of light was reversible. Therefore, common waterhemp dormancy was phytochrome-regulated. However, high temperatures overcame the inhibitory effect of FR and promoted the germination of chilled seeds.

The results of this work showed how the interactions between different environmental factors are important determining dormancy regulation, and how the response to those interactions differs dramatically among species.

COMMON POKEWEED CONTROL IN CORN AND SOYBEAN. Scott A. Nolte, Bryan G. Young and Gordon K. Roskamp, Graduate Research Assistant, Assistant Professor and Professor, Department of Plant, Soil, and General Agriculture, Southern Illinois University, Carbondale, IL 62901 and Department of Agriculture, Western Illinois University, Macomb, IL 61455.

Common pokeweed continues to be a management problem for growers. An increase in no-till production and a decrease in the use of soil residual herbicides may have allowed this weed to become more prevalent in certain areas. Growers typically use postemergent (POST) herbicides for control of common pokeweed. However, information on chemical control using POST herbicides is not well documented with the exception of local recommendations from industry and university resources. Therefore, studies were conducted at three locations evaluating the efficacy of several POST herbicides and the effect of application timing on control of common pokeweed in corn, soybean and non-crop situations.

Several herbicides were evaluated including chlorimuron, cloransulam, imazamox, thifensulfuron:chlorimuron, glyphosate, imazethapyr:imazapyr, diflufenzopyr:dicamba, dicamba dicamba:diflufenzopyr:nicosulfuron, and mesotrione. Various application timings corresponding to size and stage of common pokeweed were also evaluated. In soybean, all glyphosate alone treatments regardless of rate or timing provided at least 88% control of common pokeweed at the end of season. Control with cloransulam and thifensulfuron:chlorimuron was only 68 and 38%, respectively. Tank-mixing glyphosate with these herbicides increased common pokeweed control by at least 29%. In corn, all treatments applied early POST controlled at least 91% of common pokeweed at 56 days after the last application. Late POST treatments containing imazethapyr:imazapyr or dicamba provided 71 to 80% control while mesotrione provided 94% control of common pokeweed. Control prior to harvest was similar from all treatments with the exception of dicamba:diflufenzopyr:nicosulfuron applied late POST, which provided slightly less control. In non-crop, glyphosate was applied at 840 and 1,300 g ae/ha on 15, 30, 61 and 122 cm tall plants. Control of common pokeweed was 99% for all treatments with the exception of the low rate of glyphosate applied to 122 cm tall plants (97%). With POST herbicides available for effective control of common pokeweed, growers need to consider time of application in conjunction with herbicide selection to maximize control.

INFLUENCE OF ORGANIC MATTER AND PH WITH FLUMETSULAM ON VELVETLEAF RESPONSE. Jeffrey W. Vogel and J. Anita Dille, Undergraduate Research Assistant and Assistant Professor, Department of Agronomy, Kansas State University, Manhattan, 66506.

Flumetsulam is a soil applied, ALS inhibitor herbicide that is labeled for use in corn and soybeans to selectively control broadleaf weeds. At lower pH, the more prevalent molecular form of flumetsulam is sorbed and less available (Fontaine et al. 1991). It is expected that at low pH and high organic matter less flumetsulam will be available for plant uptake and growth reduction. The objective of this study was to evaluate velvetleaf response to variable rates of flumetsulam across different soil properties under greenhouse conditions.

Velvetleaf growth was used to indicate flumetsulam plant availability across soil properties. Seven soils were taken from the Agronomy North Farm in Manhattan, KS that varied in texture, organic matter (OM), pH, and cation exchange capacity (CEC), which had been characterized in an earlier study (Tatro et al. 2001). Approximately 450 grams of each soil was placed in ten-centimeter diameter pots. Five rates of flumetsulam were applied preemergence to the pots (untreated, 0.25x, 0.5x, 1x, and 2x; x=76 g ha^{-1}) and then five velvetleaf seedlings per pot were established within five to seven days after planting (DAP). It was a completely randomized design with five replications and was repeated. Experiment one was initiated in April 2002 and experiment two was initiated in September 2002. Height measurements were taken at 11 and 21 DAP and aboveground dry matter and number of surviving seedlings at 21 DAP. Plant response was calculated as percent reduction in average dry matter relative to untreated.

In general velvetleaf mortality for both experiments increased with increased flumetsulam rate and varied by soils, although mortality was at a higher level in September. Percent reduction in average dry matter per pot relative to untreated encompasses both seedling mortality and dry matter reduction of surviving velvetleaf. Percent reduction in average dry matter per pot increased with flumetsulam rate and was greater in September for low rates (0.25x and 0.5x) and similar across experiments at high rates, approximately 80% and 83% for 1x and 2x rates, respectively. Percent reduction in average per surviving plant dry matter relative to untreated excludes mortality, which increased with flumetsulam rate. Maximum reduction in average per surviving plant dry matter was lower compared to reduction in total pot dry matter. Soil properties explain more of the response in dry matter reduction in May than in September. Velvetleaf response to flumetsulam was not explained by pH or OM in May or September and responses were opposite to expectations with CEC and clay content in May. Range of pH and OM may not have been broad enough. For example, flumetsulam applied to a soil with a pH of 5.8 and 4.6% OM caused injury to rotational sunflowers the year following application of 70 g ha^{-1} (Lehmann et al. 1992).

SEQUENCING AND COMPARING REGIONS OF THE EPSPS GENE IN WEED SPECIES. Aaron L. Waltz, Don J. Lee, 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.

Glyphosate is rapidly becoming the most widely used pesticide in US crop production history. In large part, the widespread adoption of glyphosate for weed management is due to its broad-spectrum efficacy and to the commercialization of glyphosate-resistant crop cultivars. Virtually all agricultural fields are infested by several weed species and glyphosate is active on most green plants making it a powerful weed management tool when used in conjunction with glyphosate-resistant crop cultivars. Glyphosate was used on over 70% of the 70,000,000 acres of soybean produced in the U. S. in 2001 (National Agricultural Statistics Service 2001). Limited availability of adapted glyphosate-resistant corn hybrids has limited glyphosate use in corn to date. However, with the increase in availability of glyphosate-resistant corn hybrids, it is not unreasonable to project that 70% of the 80,000,000 acres of corn produced in the U. S. will be treated with glyphosate in a matter of a few years. Since much of the corn and soybeans are normally grown in rotation with each other there could be over 100,000,000 acres treated with glyphosate for weed control year after year. Such reliance on a single pesticide for multi-species pest control is unprecedented in US history and potentially sets the stage for an increase in glyphosate-resistant or tolerant weed species.

A number of plant and bacterial species have been engineered or selected for tolerance/resistance to glyphosate, and at least total eight glyphosate-resistant biotypes of four weed species now exist. One of these biotypes, a glyphosate-resistant goosegrass, has one single amino acid modification in common with commercially available, glyphosate-resistant corn hybrids. Some weed populations are naturally more tolerant of glyphosate as well (e.g. morningglory species).

The goal of this research is to amplify and compare regions of the EPSPS DNA sequence within weed species. Primers were developed for PCR by aligning several EPSPS sequences available through GenBank. Highly conserved base pair regions within this enzyme make this a possibility. Four forward and four reverse primers were initially selected. Amplified products from Arabidopsis, barnyardgrass, common lambsquarters, maize, redroot pigweed, shattercane, and velvetleaf were run on an agarose gel, excised, purified, and sent to Davis Sequencing (Davis, CA) for sequencing reactions. So far, the sequences obtained are very noisy and unclear. It appears that at least one of the primers has multiple targets within the Arabidopsis genome. One possibility from here is to design longer primers that will be more specific for the EPSPS gene sequence.

From the gene sequence of the EPSPS gene within important weed species, many things are possible. The gene sequences themselves may give us information about the EPSPS enzyme across species. Primers for the EPSPS gene sequence that work across multiple species would be beneficial in the process of surveying weed populations. Research into EPSPS gene families and copy number would be aided by this information as well. Another possibility is the use of EPSPS primers to utilize the power of PCR to examine EPSPS mRNA expression.

The ultimate goal of weed science research is to help producers effectively manage harmful weed populations. Understanding the basic biology of weed species is a fundamental step in developing more effective weed management programs. Understanding the variation in the EPSPS gene in and among weed species in relation to plant response to glyphosate will provide the foundation required to predict the species most likely to be successful in a glyphosate-based system and to develop effective IWM (Integrated Weed Management) programs. It is a virtual certainty that more biotypes with lessened sensitivity to glyphosate will surface as the intense use of glyphosate continues. Characterizing the diversity in the EPSPS gene in weed populations will serve as the foundation for proactive preemptive weed management programs.

WEED SEEDLING EMERGENCE AND MICROCLIMATE IN A TROPICAL ENVIRONMENT. Friday Ekeleme, Frank Forcella, David Archer, and David Chikoye, Assistant Professor, Research Agronomist, Agricultural Scientist, and Research Scientist, Michael Okpara Agricultural University, Umudike, Nigeria; USDA-ARS, Morris, MN 56267; and International Institute of Tropical Agriculture, Ibadan, Nigeria.

Tropic ageratum (*Ageratum conyzoides*) is an important annual weed in tropical cropping systems. Better and more timely strategies for its control might be developed through a more thorough understanding of its emergence behavior. Seedling emergence of tropic ageratum was monitored periodically and standard weather data were collected daily for each of four years at IITA, Ibadan, and for one year at Umudike. The weather data were used in the SHAW (Soil Heat and Water) model to estimate soil temperature and soil water potential at the 2 cm depth. The estimated variables were converted to soil hydrothermal time (HTT). Cumulative relative emergence (CRE) values for all four years from Ibadan were compared iteratively against HTT using a series of base temperatures and base water potentials. The four sets of data “collapsed” best upon one another when HTT was calculated using a base temperature of 28 C and a base water potential of – 0.02 MPa. The aggregate data fit a Weibull function of the form: CRE = 100*(1-e^(0.0054*HTT^1.4268)). This model was used to simulate emergence of tropic ageratum at Umudike, and the simulated results compared favorably with observations: r^2 = 0.98, and the coefficient describing the dependence of observed emergence on simulated emergence was near unity (0.97). Both statistics indicate that the model simulated emergence of tropic ageratum dependably.

DELAYED WEED EMERGENCE AND ESCAPE FROM CONTROL IN GLYPHOSATE-TOLERANT SOYBEAN. Susan Hennen, Julio Scursoni, Frank Forcella, and Jeff Gunsolus; Teacher, Instructor, Research Agronomist, and Professor; St Mary's School, Morris, MN 56267; University of Buenos Aires, Argentina; USDA-ARS, Morris, MN 56267; and University of Minnesota, St Paul, MN 55108.

Delayed weed emergence may be an important factor governing the type of species and number of individual plants that escape control in cropping systems employing glyphosate-tolerant crops. We examined this possibility in field plots within the state-wide soybean herbicide trials conducted by the University of Minnesota Research and Outreach Centers at Lamberton, Morris, Potsdam, and Waseca (2 sites). Weed emergence was monitored periodically in weedy check plots, and end of season weed populations were assessed in the one-pass and two-pass glyphosate treatments. The number of escaped plants in the two-pass treatment was only a small fraction of those that escaped control in the one-pass treatment. Nevertheless, plants that escaped control typically belonged to species that had low cumulative relative emergence values at the time of glyphosate applications. Common lambsquaters (*Chenopodium album*) was the species that most often escaped control by glyphosate.

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SUSCEPTABILITY TO GLYPHOSATE OF WEED ESCAPES IN GLYPHOSATE-TOLERANT SOYBEAN. Gary Amundson, Julio Scursoni, and Frank Forcella, Engineering Technician, Instructor, and Research Agronomist; USDA-ARS, Morris, MN 56267; and University of Buenos Aires, Argentina.

We hypothesized that one of many mechanisms by which weeds could escape control by glyphosate in cropping systems that employ continual use of glyphosate-tolerant crops was evolved tolerance to this herbicide. To examine this hypothesis, we collected seeds that were produced by plants that escaped control by glyphosate as well as seeds of plants not exposed to glyphosate. All seeds were collected in plots maintained in state-wide herbicide trials at university experiment stations in Minnesota, Iowa, Missouri, Arkansas, and Louisiana. Treatments from which seeds were collected typically were the weedy check, one-pass glyphosate, and two-pass glyphosate treatments. Seeds were germinated in the greenhouse the following year, thinned to four seedlings per pot, and exposed to a 10% label rate of glyphosate in a spray cabinet at either of two stages of seedling development (<15 cm tall and <30 cm tall). Two weeks after exposure the seedlings were measured for survival and various gross morphological traits. Most plants showed no differential susceptibility to glyphosate based upon 0, 1, or 2 exposures to this herbicide the previous year. However, some species did show a differential response: common lambsquarters (*Chenopodium album*) and prickly sida (*Sida spinosa*) were two species that showed greater tolerance and other species when exposed to a 10% label rate of glyphosate. Survivial, height, leaf number per plant, and dry weight were greater for seedlings grown from seeds whose maternal parents previously were exposed to glyphosate than those from parents grown in weedy check treatments.

WEED SPECIES DYNAMICS IS GLYPHOSATE-RESISTANT CROPPING SYSTEMS. Shannon M. Oltmans and Richard K. Zollinger, Graduate Research Fellow and Associate Professor, Plant Sciences Department, North Dakota State University, Fargo, ND 58105.

Glyphosate-resistant crops, such as canola, corn, and soybean, are grown extensively throughout North Dakota and northwestern Minnesota. Glyphosate-resistant wheat may be available to North Dakota producers as early as 2005. A field experiment was conducted to evaluate volunteer glyphosate-resistant wheat control, weed species dynamics, and selection of glyphosate-resistant weed species with four herbicide sequences (i.e., glyphosate applied once/yr, glyphosate applied twice/yr, conventional herbicide, and a two-yr sequence of glyphosate applied twice/yr followed by conventional herbicide the subsequent yr) in a glyphosate-resistant soybean-wheat cropping sequence.

Volunteer glyphosate-resistant wheat was controlled with quizalofop-P in glyphosate-resistant soybean. Volunteer glyphosate-resistant wheat densities present at harvest ranged from 0 to 0.3 plants/m^2. Losses from competition were minimal because of small plant size. Most glyphosate-resistant wheat plants were in the one- to two-leaf stages. Conventional herbicide may favor an increase in kochia and wild buckwheat, while glyphosate applied once/yr may favor an increase in foxtail species, pigweed species, and common lambsquarters. The inability to control late-season weed emergence with one glyphosate application may have contributed to an increase in densities. The increase in weed species densities when glyphosate was applied once/yr appears to be a mechanism of avoidance. There were no glyphosate-resistant weeds observed following 3 yr of glyphosate applied twice/yr. Continued monitoring of weed species dynamics and selection of glyphosate-resistant weeds is necessary in glyphosate-resistant cropping systems.

WEED DIVERSITY AND YIELD IN GLYPHOSATE-TOLERANT SOYBEAN FROM MINNESOTA TO LOUISIANA. Dean Peterson, Julio Scursoni, and Frank Forcella, Agricultural Science Technician, Instructor, and Research Agronomist; USDA-ARS, Morris, MN 56267; and University of Buenos Aires, Argentina.

Since their introduction in 1996, the use of glyphosate-tolerant soybean has grown from 5% of the total soybean acreage to 71% in 2001 or 54 million acres out of 75.4 million acres planted in the United States. The widely excepted use of this technology in North America facilitates examination of this new technology on a regional basis. In addition, this research provides an opportunity to compare several factors and address some of the current concerns in the European community regarding glyphosate-tolerant crops. The objectives of this study were to observe difference in yields along a latitudinal transect and compare yields to changes in weed diversity in glyphosate-tolerant soybean production systems. Data were collected in 2001 and 2002 from established weed management trials at 12 experiment stations along a north-south gradient throughout the central United States. The states (and number of experiment stations) included Minnesota (4), Iowa (3), Missouri (2), Arkansas (2), and Louisiana (1). Yield and weed diversity data were collected from the following selected herbicide treatments: One-Pass Glyphosate, Two-Pass Glyphosate, Standard Pre plus Glyphosate, Standard Pre only or Pre plus Standard Post or Standard Post only, and Weedy Check. Field methods and calculations included: yield samples collected by plot, density recorded by species, percent cover recorded by species, Shannon diversity (H') calculated by plot, effective species richness ($e^{H'}$) calculated by plot, 3 to 4 plots per treatment sampled at each location, and field sampling occurred in autumn, just prior to harvest. For crop yields, there were no latitudinal trends for weedy checks, possible slight decreases in maximum yield with latitude for 2-Pass Glyphosate and Pre plus Glyphosate treatments, and strong positive increases in maximum yield with latitude for 1-Pass Glyphosate and Pre/Post treatments. For weed diversity, there were not latitudinal trends, but distinct treatment effects: weedy checks had highest weed densities, but not necessarily the highest $e^{H'}$, and this was consistent between years; One-Pass Glyphosate always had high diversity; Standard Pre + Glyphosate had the best weed control and lowest diversity; and Two-Pass Glyphosate and Standard Pre + Post also had low diversities. Where weed species diversity is concerned, the One-Pass Glyphosate treatment allowed for the expression of the greatest diversity. In this case, the glyphosate suppressed the dominant species and allowed less common species too express themselves in the population, thereby increasing species richness. If weed diversity is valued by society, as in Europe, farmers can maintain better diversity with a One-Pass Glyphosate application than with traditional treatments and still maintain high yields, but only at higher latitudes. Below 40 N latitude, yields in the One-Pass Glyphosate treatment decreased by about 10%, and continued to decrease by about 2% per degree of latitude. There are many factors to consider when using latitude as an index. These factors may include: temperature, rainfall, growing degree days, varieties, cropping histories, and tillage management practices. Which of these factors explains the loss of yield in One-Pass Glyphosate is unknown.

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REGIONAL VARIABILITY IN SEED PRODUCTION OF ANNUAL WEEDS. Kathrin Schirmacher*, and J. Anita Dille, Graduate Research Assistant and Assistant Professor, Agronomy Department, Kansas State University, Manhattan, KS 66506, Corey J. Guza and James J. Kells, Graduate Research Assistant and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824, Christy L. Sprague, Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801, and George O. Kegode, Assistant Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Biological processes driving regional variability in weed populations are poorly understood because weed species, environmental conditions, and cropping systems vary across the Midwest. Quantifying weed population dynamics via potential seed production on a regional scale will contribute to the database that is founded on biological and ecological interactions. The objective was to characterize the regional variability in potential seed production of common lambsquarters, giant foxtail or green foxtail, and velvetleaf relative to four cohort emergence times in corn production systems across the Midwest. Field experiments were conducted in 2001 and 2002 in Illinois, Kansas, and Michigan, and in 2002 in North Dakota. Experimental whole-plots included the different weed species grouped by cohort, with cohort identified at a given corn growth stage (0, VE, V1, and V3). Weeds were harvested at or shortly after physiological maturity and average seed production per plant was determined. Illinois and Michigan showed low velvetleaf seed production and no significant differences across cohorts observed. Greater amount of velvetleaf seed were produced by earlier seeded cohorts in Kansas and North Dakota producing 2055 and 5843 seed plant^{-1}, respectively compared to later cohorts. No cohort by location interaction was found for common lambsquarters ($p=0.654$), and no differences across cohorts ($p=0.477$). Giant foxtail (and green foxtail in North Dakota) showed the greatest variability across locations. In 2001, only Kansas showed differences in seed production for giant foxtail across cohorts and showed significantly greater seed production with the first cohort planting (0) than with later emerging cohorts. In 2002, no differences across time of plantings for giant foxtail were noted for Illinois and Michigan. In Kansas and North Dakota, earlier plantings showed greater overall average seed production producing 4242 and 1158 seed plant^{-1} respectively at the first cohort planting (0), and produced 0 and 105 seed plant^{-1} respectively at the V3 growth stage. Seed production variability across locations was likely related to regional variability in rainfall patterns during the years of study. Furthermore, variable crop seeding rates and planting dates across the region could contribute to creating a more competitive crop against the weeds.

FECUNDITY OF ANNUAL WEEDS BY COHORT EMERGENCE TIMES IN CORN. Kathrin Schirmacher* and J. Anita Dille, Graduate Research Assistant and Assistant Professor, Agronomy Department, Kansas State University, Manhattan, KS 66506.

Few studies have quantified seed production associated with different cohorts (seedlings that emerge at nearly the same time). Cohort emergence time relative to the crop and inherent fecundity are critical in quantifying weed interference, as well as for understanding weed productivity and future seedbank dynamics. Therefore, the objective of this research was to evaluate the effect of weed emergence at different corn growth stages on the fecundity of four cohorts of eight annual weeds. Field experiment conducted near Manhattan in 2001 determined seed production of individual plants of common lambsquarters, common sunflower, Palmer amaranth, velvetleaf, fall panicum, giant foxtail, large crabgrass, and shattercane competing with corn. Each experimental whole-plot included the eight species grouped by cohort, with cohort identified at a given corn growth stage (0, VE, V1, and V3). Across weed species, cohorts planted earlier had better plant establishment and generated a greater number of seeds on a per plant basis. Common lambsquarters, common sunflower, and Palmer amaranth planted at V3 produced no seeds; giant foxtail, fall panicum, large crabgrass, and velvetleaf yielded one seed-producing plant from the six replicates, and shattercane only produced four reproductive plants. Poor emergence of common lambsquarters and poor establishment of fall panicum provide limited information on seed production. Emergence, establishment, and seed production of giant foxtail, shattercane, and velvetleaf were less variable within a cohort when compared to other species. Seed production followed a gradual decline across cohorts with giant foxtail producing 10106, shattercane 2478, and velvetleaf 1059 seed plant^{-1}, at the first cohort planting (0). In summary, plants of earlier cohorts were more successful at completing their reproductive life cycles and generated more potential offspring than cohorts planted at a later corn growth stage. Given the relationship between emergence and seed production, the control of early emerging plants or those that escape chemical control is necessary to reduce impact on future seedbank size.

GROWTH AND FITNESS OF COMMON SUNFLOWER AND PRAIRIE SUNFLOWER AS AFFECTED BY IMIDAZOLINONE RESISTANT GENE(S). Rafael A. Massinga and Kassim Al-Khatib. Department of Agronomy, Kansas State University , Manhattan, KS 66502.

Field studies were conducted under greenhouse and field conditions to evaluate the growth and fitness of progeny of domesticated imidazolinone (IMI)–resistant sunflower x wild sunflower species. Under greenhouse conditions, common sunflower (*Helianthus annuus*) and prairie sunflower (*H. petiolaris*) were grown in individual pots. Photosynthesis, leaf area and total dry weight were measured 10, 20, 30, 40, 50 and 60 days after planting. In addition, progeny of domesticated IMI–resistant sunflower x wild sunflower species, were grown in the greenhouse and treated at 2 to 4 leaf stage with 40 g ai ha^{-1} of imazamox, to determine presence of imidazolinone resistance. Plants that survived imazamox treatment (IMI-resistant) were allowed to grow in greenhouse, and at 6 leaf stage were transplanted to field. IMI-resistant and IMI-susceptible of common and prairie sunflower plants were established in field as replacement series with 10:0, 7:3, 5:7, 3:7 and 0:10 R:S (resistant : susceptible) mixture rates. Days to flower, plant height and 100 seed weight were determined for resistant and susceptible plants at each combination. IMI-resistant and IMI-susceptible common and prairie sunflower plants did not differ in photosynthesis rate, leaf area and dry weight. IMI-susceptible common sunflower growing under no competition was taller than IMI-resistant plants whereas, under competition plant height was greater in IMI-resistant plants. IMI-resistant prairie sunflower was taller than the IMI-susceptible plants under competition and no competition. In general, IMI-resistant plants flowered earlier than the IMI-susceptible plants, but the flowering period overlapped considerably suggesting that the IMI-resistant and wild susceptible plants are likely to hybridize. No differences were observed in number of heads per plant and 100 seed weight between IMI-resistant and IMI-susceptible plants for both common and prairie sunflower. The results of this study did not show any competitive advantage of the IMI-resistant sunflowers over the susceptible the plants.

GENE FLOW FROM IMIDAZOLINONE RESISTANT DOMESTICATED SUNFLOWER TO COMMON SUNFLOWER AND PRAIRIE SUNFLOWER. Rafael A. Massinga and Kassim Al-Khatib, Research Associate and Associate Professor, Department of Agronomy, Kansas State University Manhattan, KS 66506.

Imidazolinone (IMI)-resistant gene flow from domesticated sunflower to IMI-susceptible common sunflower (*Helianthus annuus*) and prairie sunflower (*H. petiolaris*) was studied. Under greenhouse conditions, pollen from IMI-resistant domesticated sunflower was applied to flower heads of IMI-susceptible common and prairie sunflower. In addition, field studies were conducted in 2000 and 2001 near Manhattan Kansas, to evaluate IMI-resistant gene flow from IMI-resistant domesticated sunflower to common and prairie sunflower under natural conditions. Common and prairie sunflower were planted in concentric circles at distances of 2.5, 5, 15 and 30 meters around a densely planted IMI-resistant domesticated sunflower species. For both greenhouse and field studies, IMI-resistant gene flow was determined by treating the progeny of both wild species with 40 g ai ha^{-1} imazamox to determine presence of imidazolinone resistance. The outcrossing rate was 92% for common sunflower and 90% for prairie sunflower. The plants that survived the treatment with imazamox were allowed to grow in greenhouse and were backcrossed to the corresponding wild parents. The progeny of the backcross showed a 1:1 ratio segregation of resistant and susceptible plants. In the field, resistance to imazamox was detected up to 30 m from the pollen source for both species. In addition, resistance to imazamox decreased as distance from the pollen source increased. In 2000, the resistance ranged from 11 to 22% at 2.5 m from the pollen source and from 0.3 to 5.6% at 30 m. In 2001, the levels of resistance did not exceed 7% and 2% at 2.5 and 30 m from the pollen source, respectively. Overall greater levels of resistance in the field were observed in prairie sunflower than in common sunflower. The results of this study showed that IMI-resistant domesticated sunflower outcrosses with common sunflower and prairie sunflower and backcross of resistant hybrids to wild parents occur successfully increasing the potential for resistance spread.

EMERGENCE AND REPRODUCTIVE DEVELOPMENT OF COMMON MALLOW AS INFLUENCED BY IRRIGATION AND CROP CANOPY. John Cardina, Kerry Cluney and Douglas Doohan, Associate Professor, Graduate Research Assistant and Associate Professor, Department of Horticulture and Crop Science, The Ohio State University, Ohio Agricultural Research and Development Center, Wooster, OH 44691.

To minimize crop losses due to weed competition, it is necessary to control weed emergence during the critical period of crop canopy formation and to disrupt seed production in order to minimize the amount of seed released into the seedbank. A study was conducted in 2001 and 2002 to examine the effects of irrigation and soybean canopy on the emergence pattern and rate of reproductive development of common mallow (*Malva neglecta* Wallr.). ANOVA and non-linear regressions showed that irrigation and crop did not affect common mallow emergence patterns. Due to adequate rainfall and little crop competition early in the season, differences in soil moisture and soybean canopy did not appear until much of the emergence had ceased. Common mallow plants emerging on different dates were monitored weekly and scored according to the first observation of four reproductive stages: bud, flower, pod and mature pod. A maturity index was used to measure the rate at which plants growing in different irrigation and crop regimes reach reproductive maturity. Crop had a greater impact on the rate of common mallow reproductive development than irrigation. Mallow plants emerging in non-cropped plots earlier in the season appeared to produce similar amounts of seed, regardless of irrigation regime. The presence of a crop canopy had a greater impact on the productivity of common mallow when irrigation was lacking. Plants emerging after mid-June were not likely to flower or mature under crop competition.

EVALUATION OF KOCHIA CONTROL AND GRAIN SORGHUM RESPONSE TO FLUROXYPYR. 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.

Most herbicides currently registered for postemergence use in grain sorghum have limited crop selectivity or do not provide adequate control of some important weeds such, as kochia. Fluroxypyr is a pyridine-based herbicide that effectively controls kochia and other annual broadleaf weeds in cereal grain crops and has potential for use in grain sorghum. Field studies were conducted at Hays, KS in 2001 and Arlington, KS in 2002 (1) to evaluate fluroxypyr efficacy and crop safety as affected by tank mixtures applied at two growth stages of sorghum, and (2) to compare the effects of adjuvants on fluroxypyr efficacy. Experiments were overseeded with kochia and *S*-metolachlor was applied preemergence at 660 g ai ha^{-1} to control grass weeds. Regardless of growth stage (8 to 13 or 20 to 25 cm tall sorghum), fluroxypyr at 140 g ae ha^{-1} tank mixed with atrazine and crop oil concentrate (COC) at 560 g ai ha^{-1} + 1% v/v or metsulfuron and non-ionic surfactant (NIS) at 2.1 g ai ha^{-1} + 0.5% v/v controlled kochia more than fluroxypyr at 140 g ha^{-1} plus NIS or dicamba + atrazine at 310 g ae ha^{-1} + 590 g ha^{-1}; each were more effective than atrazine + COC at 560 g ha^{-1} + 1% v/v. Fluroxypyr + metsulfuron + NIS severely stunted crop growth and caused temporary chlorosis in both years, but did not reduce grain yield in 2001. Yield was not determined in 2002 because of drought. In the adjuvant study, none of the adjuvants evaluated (COC, methylated seed oil, Herbimax, LI 700, Liberate, Dispatch 111, or Activator 90) enhanced kochia control with fluroxypyr at 105 g ha^{-1}.

GRAIN SORGHUM TOLERANCE TO POSTEMERGENCE MESOTRIONE APPLICATIONS. Jason N. Miller and David L. Regehr, Graduate Research Assistant and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Mesotrione is a new class of chemistry with a new mode of action for post-emerge broadleaf weed control in corn. It controls tough broadleaf weeds that are resistant to triazine and ALS-inhibiting herbicides. The objectives were to determine how mesotrione tank-mix combinations and application timing affect grain sorghum, while providing adequate broadleaf weed control. The study was conducted near Manhattan, KS during the 2002 growing season. Mesotrione was tank-mixed with standard post-emerge sorghum herbicides, and applied either early or late post. All tank-mix combinations contained 105 g/ha mesotrione and 1% v/v COC and 2.5% v/v UAN. Plots were visually evaluated for sorghum injury and Palmer amaranth control. All early post treatments caused severe sorghum bleaching ranging from 40 to 65 percent 6 days after treatment (DAT). The most severe injury occurred from mesotrione tank-mixed with 280 g/ha atrazine or tank-mixed with 280 and 140 g/ha 2,4-D amine and low-vol ester. Injury had decreased significantly 27 DAT across all treatments, however mesotrione tank-mixed with the atrazine or 2,4-D was still the most severe. Mesotrione applied late post was better tolerated by the sorghum with little injury. Late post injury averaged 20 percent, with no significant differences between treatments. Palmer amaranth control in the early post treatments ranged from 70 to 90 percent with no significant differences. In the late post treatments, Palmer amaranth control ranged from 15 to 45 percent. Sorghum in the early post treatments averaged 2800 kg/ha, while the late post treatments were not harvested due to inadequate Palmer amaranth control. An adjacent experiment, under identical sorghum and weed conditions, included a treatment of 1.7 kg/ha atrazine and COC with no mesotrione, applied early post-emerge. There, Palmer amaranth control was excellent, with no herbicide stress on the crop, and sorghum yielded 5900 kg/ha. Much of this yield difference was attributed to the sorghum injury and slow recovery when treated early post-emerge with mesotrione.

WEED CONTROL IN CORN WITH MESOTRIONE AND ATRAZINE COMBINATIONS APPLIED PREEMERGENCE. Scott L. Bollman and James J. Kells, Graduate Research Assistant and Professor, Department of Crop and Soil Science, Michigan State University, East Lansing, MI 48824; Thomas T. Bauman, Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907; Mark M. Loux, Associate Professor, Department of Horticulture and Crop Science, Ohio State University, Columbus, OH 43210; Charles H. Slack, Department of Agronomy, Agricultural Research Specialist, University of Kentucky, Lexington, KY 40506; Christy L. Sprague, Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61820.

Atrazine continues to be an important component of preemergence weed control in corn. The combination of mesotrione and atrazine has been effective in controlling several troublesome broadleaf weeds. An understanding of the response of weeds to atrazine and mesotrione is needed for the most cost effective control strategies. A study was conducted at seven sites in 2002 to determine the optimum rates of mesotrione and atrazine applied preemergence for consistent control of velvetleaf, common ragweed, giant ragweed, and common cocklebur.

Mesotrione was applied at rates of 0, 53, 105, 158, and 210 g ai/ha and atrazine was applied at rates of 0, 280, 560, 1120, and 1780 g ai/ha. Each site received s-metolachlor at the recommended rate for each soil type. Weed control (visual) and weed densities were evaluated 30, 45, and 60 DAT. Plots were also harvested for corn yield determination.

Neither atrazine nor mesotrione applied alone controlled all four target weeds. All treatments with mesotrione resulted in 85 percent or greater control of velvetleaf. Giant ragweed control increased as mesotrione rate and atrazine rate increased. The most effective control of giant ragweed was at the highest rates of the two herbicides in combination. In Urbana, all mesotrione and atrazine treatments were effective for controlling common cocklebur, however only the highest rates of both herbicides provided greater than 85 percent control in Lexington. All rates of both herbicides controlled common ragweed in South Charleston, OH, while only combinations of mesotrione and atrazine were effective in East Lansing. The highest level of control for the target weed species was obtained by the combinations of both herbicides.

INTERACTION OF MESOTRIONE WITH PHOTOSYNTHETIC INHIBITORS. Julie A. Abendroth, Alex R. Martin, and Fred W. Roeth, Graduate Research Assistant, Professor, and Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE 68583-0915.

After preliminary research, a study was conducted in Clay Center, NE, to further investigate the interaction that occurs from the combination of mesotrione with photosynthetic inhibitors, specifically photosystem II inhibitors (PS II). Mesotrione was tested at five different rates: 0.0078, 0.016, 0.031, 0.063, and 0.094 lb ai/A. The PS II herbicides tested were atrazine, at rates of 0.125, 0.25, 0.50 lb ai/A, metribuzin at 0.75 and 1.5 oz ai/A, and bromoxynil, at 0.0625 and 0.125 lb ai/A. Treatments consisted of either mesotrione alone, a PS II alone, or a combination of the two. Percent necrosis at 6 days after treatment (DAT) and percent control at 12 DAT were recorded on velvetleaf, sunflower, and palmer amaranth. The expected treatment means were found by subjecting the observed treatment means to a multiplicative survival method, as described by Colby in 1967. Differences between observed and expected values were compared using an lsd at $\alpha = 0.05$.

Synergism occurs when the observed response from two herbicide's joint application is greater than the expected response. Synergistic activity occurred between mesotrione and PS II inhibitors with all three weed species, excluding the combination of mesotrione and metribuzin on velvetleaf. With this and some other mesotrione + PSII combinations, the rates of herbicides used were too high to differentiate between additive and synergistic behavior, at one or both of the rating times. Overall, synergism was observed for velvetleaf and sunflower only in regards to the time of death. Death was quickened by the combination of mesotrione with a PS II; however, none of the observed responses for the combinations proved to have greater significant efficacy than the expected responses at 12 DAT. With respect to palmer amaranth, rates appear to be in the appropriate range for determining synergism, which occurred at both 6 DAT and 12 DAT. At 12 DAT, the expected response for mesotrione (0.016 lb ai/acre) and bromoxynil (0.0625 lb ai/acre) is 56%; however, the observed percent control was 95%.

ROW SPACING AND POPULATION EFFECT ON YIELD AND WEED CONTROL IN HERBICIDE TOLERANT CORN. 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.

Studies were conducted over a two-year period to investigate the effects of row spacing, plant population and herbicide treatment on the production of glyphosate and glufosinate tolerant corn under irrigated conditions. In 2001 corn was planted in at three populations, 39,500 79,000 and 118,500 seed per hectare, and at 79,000 seed per hectare in 2002 with all in 38, 56, and 76 cm rows. Each of these combinations was then treated with five herbicide treatments. In the glyphosate system: a pre-emergence application of metolachlor/atrazine followed by an application of glyphosate, a single application of glyphosate, two applications of glyphosate, a hand weeded, and a weedy check, in 2002 two applications of a 0.5 X rate of glyphosate was substituted for the single application, and a treatment containing conventional herbicides was substituted for the hand weeded check. In the glufosinate system: a pre-emergence application of metolachlor/atrazine followed by an application of glufosinate, a single application of glufosinate, two applications of glufosinate, a hand weeded, and a weedy check, in 2002 an application of a glufosinate/atrazine was substituted for the single application of glufosinate, and a treatment containing conventional herbicides was substituted for the hand weeded check. The study was setup as a split plot factorial arrangement in 2001 and a split plot in 2002 with four and three replications respectively. Planting population significantly impacted corn yields in 2001, while row spacing was not significant in either year. All of the herbicide treatments yielded significantly higher than the weedy check in both years of the study. Weed biomass was significantly higher in the low population treatments. Row spacing significantly impacted weed biomass in the glufosinate system in 2001, however, there was a trend towards less weed biomass with reduced row width with glufosinate in 2002 and glyphosate in 2001 and 2002. Most herbicide treatments provided greater than 90% control of broadleaf and grass weeds, both years, the only exceptions were the single application of glyphosate, single application of glufosinate, two applications of glufosinate in 2001 and two applications of a 0.5 X rate of glyphosate in 2002.

CORN GROWTH AND YIELD AS AFFECTED BY TIME OF WEED EMERGENCE. Corey J. Guza and James J. Kells, Graduate Research Assistant and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Corn yield loss from weeds can be affected by weed species and emergence timing relative to corn emergence. The effect of weed species and emergence time on weed growth and corn yield was examined in Michigan in 2001 and 2002. Weeds examined were giant foxtail, common lambsquarters, and velvetleaf. Weeds were planted at four different timings associated with corn growth stage; corn planting (cohort one), corn emergence (cohort two), V1 (cohort three), and V3 (cohort four). Cohort two was not planted in 2002 due to heavy rainfall and rapid corn emergence. Weed growth was compared using maximum weed volume within each cohort. Maximum weed volume was also used to compare weed growth among cohorts.

Weeds planted at the time of corn planting produced the greatest weed volume. In 2001, in cohort one, velvetleaf produced a greater weed volume than giant foxtail, while giant foxtail produced a greater weed volume than common lambsquarters. In cohort two, velvetleaf produced the greatest weed volume. There were no differences in weed volume among the weeds at cohorts three and four in 2001. In 2002, velvetleaf produced the greatest volume in cohorts one and three. There were no differences in weed volume at cohort four. In 2001 and 2002, greatest giant foxtail growth occurred in cohort one. There were no differences in common lambsquarters growth between any of the cohort timings in 2001. However, in 2002, common lambsquarters growth was greatest in cohort one. In both years, velvetleaf growth was greatest in cohort one and declined with later cohort timings.

Giant foxtail had no effect on corn yield regardless of cohort timing. Common lambsquarters reduced corn yield in cohort one and two in 2001 and in cohort one and three in 2002. Velvetleaf reduced corn yield in cohort one in 2001 and cohort one and three in 2002.

MANAGEMENT OF PROBLEMATIC WATERHEMP IN GLYPHOSATE-RESISTANT CORN.
Christopher L. Schuster and Reid J. Smeda, Graduate Research Assistant and Assistant Professor, Agronomy Department, University of Missouri, Columbia, MO 65211.

Common waterhemp is a significant weed problem in crop production systems in the central United States. Recent adoption of glyphosate resistant crops has led to widespread dependence upon glyphosate for control of common waterhemp. Despite its sensitivity to glyphosate, waterhemp continues to increase in severity. The release of glyphosate-resistant corn will also impact waterhemp; full season management may necessitate a multi-program approach. Several herbicide programs are available to control waterhemp in glyphosate-resistant corn, but each may require additional management considerations. Field studies were established at two locations in northeast Missouri to evaluate multiple herbicide programs for effective season-long control of waterhemp in corn. This study assessed one-pass preemergence (PRE) and postemergence (POST) applications, two-pass POST applications, and two-pass PRE followed by POST applications. Waterhemp response was evaluated visually at 2 and 5 weeks after treatment (WAT) and by recording waterhemp suppressed by PRE herbicides at the time of POST applications. Results indicated that herbicide programs which included a PRE of acetochlor or acetochlor + atrazine suppressed waterhemp emergence for an additional 7 – 24 days compared to treatments with no PRE herbicide. Waterhemp was suppressed for 54 days at Novelty in 2001 with a combination of metolachlor, atrazine, and isoxaflutole. Results show that when averaged over both locations a single POST application of glyphosate + atrazine resulted in 92 and 75% control of waterhemp 2 and 5 WAT, respectively. Metolachlor + atrazine followed by diflufenzopyr + dicamba, dicamba + atrazine, or mesotrione provided season-long control of waterhemp (>95%). A split application of glyphosate + atrazine followed by glyphosate resulted in 99% waterhemp control 5 WAT. PRE applications of acetochlor or acetochlor + atrazine followed by glyphosate or glyphosate + atrazine resulted in >97% control of waterhemp 5 WAT. Results indicate that effective management of waterhemp in glyphosate-resistant corn should include a PRE followed by POST or multiple POST (two-pass program).

WEED CONTROL SYSTEMS FOR IMIDAZOLINONE-TOLERANT CORN. David Johnson, Brian Dahlke, Jamie Retzinger, Kristine Schaefer, Ken Carlson, Shawn Chapman, Tom Hayden, and Bill O'Neal, BASF Corp., St. Paul, MN.

The premix herbicide imazethapyr plus imazapyr in a 3:1 ratio controls 55 key grass and broadleaf weeds in imidazolinone-tolerant corn. However, imazethapyr plus imazapyr will not control ALS-resistant common waterhemp, common ragweed, and larger giant ragweed (greater than four inches tall or four leaf stage), so tank mixes are recommended for adequate control. In 2002 we evaluated several tank-mix partners added to imazethapyr plus imazapyr for control of these weeds, including dicamba plus diflufenzopyr in a 2.5:1 ratio, dicamba, and atrazine. When applied alone, imazethapyr + imazapyr applied at 0.056 lb ai/a controlled large crabgrass, barnyardgrass, woolly cupgrass, fall panicum, giant foxtail, green foxtail, shattercane, velvetleaf, redroot pigweed, common lambsquarters, common sunflower, and Pennsylvania smartweed greater than 90%, but control of ALS-resistant common waterhemp and larger giant ragweed (>4 inches) was approximately 30 and 50%, respectively. Adding atrazine at 0.45 lb ai/a improved activity on common waterhemp and larger giant ragweed by 20-40%. However, adding dicamba plus diflufenzopyr (0.131 lb ai/a) or dicamba (0.25 lb ai/a) improved control of both weeds to over 90%. In sequential application studies, residual common waterhemp control was best (>95%) when dimethenamid-P was applied preemergence at 2/3X rate for the soil type, followed by imazethapyr plus imazapyr tank-mixed with a dicamba-containing product postemergence. These results show weeds such as ALS-resistant common waterhemp and larger giant ragweed can be successfully controlled in imidazolinone-tolerant corn systems based on imazethapyr plus imazapyr tank mixed with dicamba.

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Late-Season Common Waterhemp Interference in Corn. Lawrence E. Steckel* and Christy L. Sprague, Graduate Research Assistant and Assistant Professor, Crop Sciences Department, University of Illinois, Urbana, IL 61801.

Common waterhemp is an annual weed species that has become a major problem in Illinois row crops. This weed species has been found to reduce yield in soybean and grain sorghum. However, little research has been conducted on how competitive common waterhemp is in corn. In 2000, 2001 and 2002 a study was conducted to determine the competitive ability of common waterhemp in corn at Urbana, Illinois. The objective of this experiment was to determine the competitive ability of common waterhemp that emerges after the corn crop. The study evaluated common waterhemp interference after corn stages V4, V6, V8, V10, V12, V14, and season-long. Corn plots were kept weed-free with glyphosate at 841 gm a.e./ha until the designated corn growth stage. At that time common waterhemp seeds were sown and allowed to emerge. Common waterhemp densities averaged 80 plants/m^2 in each year of the study. Photosynthetic active radiation (PAR) was measured 3 times in the middle 2 rows at each corn stage listed above, as well as VT. In addition to PAR, common waterhemp biomass per square meter and seed production per female plant was measured. Corn grain yield was also collected in the fall. The environment each year had a significant impact on the interference potential of common waterhemp. Common waterhemp regardless of emergence time did not affect corn grain yield in 2000. Common waterhemp that emerged at the V4 and V6 corn stages reduced yield in 2001 and 2002 compared with the weed-free control. Common waterhemp that emerged at the V4 and V6 corn stages also developed the most biomass (> 36g/m^2). Common waterhemp that emerged from the V8 to V14 corn stages produced less than one gram/m^2 of biomass. In 2000 the PAR measured throughout the growing season for any of the interference treatments compared with the weed-free control was not different. However, in 2001 and 2002 common waterhemp that was allowed to compete after the V4 and V6 corn stages allowed less PAR to reach the soil surface compared with the weed-free control.

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 and 2002 on Mexico silt loam, Putnam silt loam, and a Grundy silt loam soils respectively, to determine the effects of common waterhemp interference on corn growth, biomass, nitrogen accumulation, and yield. Ammonium nitrate fertilizer (NH_4NO_3, 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 densities. Yield was not reduced at sites that had adequate season-long moisture via irrigation. All other locations had yield reduction from season long competition. Waterhemp densities of 369 to 445 plants m^{-2} reduced yield 17 to 36% depending on removal timing. Lower densities (35 to 82 plants m^{-2}) reduced yields 6% when allowed to remain with corn season long. In Columbia 2001, waterhemp biomass contained 3.8% N when it was 8 cm tall, but only 2.0% N when it was 38 cm tall. In 2002, waterhemp contained between 4.4 and 5.1% N. This suggests that N is accumulated in greater quantities when soil moisture is not limiting. On a per hectare basis, waterhemp accumulated 3.3 and 15.6 kg of N by the time it was 38 cm tall in 2001 and 2002 respectively, while corn biomass accumulated 57.2 and 81.9 kg N. This indicates that waterhemp is capable of accumulating N at a very rapid rate early in the growing season. Soil moisture deficits were observed at 4 of the 6 removal timings at high waterhemp densities, while no water deficits were observed with low waterhemp densities. Corn leaf color as measured by the SPAD^{tm} meter correlated with plant tissue analysis for nitrogen (R^2=0.82). When sites were grouped by waterhemp density there was only one instance where nitrogen content of corn was reduced early in the season with high waterhemp densities.

INFLUENCE OF CORN ON COMMON WATERHEMP GROWTH AND FECUNDITY. Dawn E. Nordby and Robert G. Hartzler, Graduate Assistant and Professor, Department of Agronomy, Iowa State University, Ames, IA 50011.

Common waterhemp is native to the Midwest, although it has only developed into a serious problem in corn and soybeans in the last decade. Four experiments were conducted in Central Iowa during the 2001 and 2002 growing seasons to evaluate the effect of delays in waterhemp emergence in corn planted in 38 and 76 cm rows. Four emergence cohorts were established in each experiment corresponding to the VE, V3, V5, and V8 stage of corn development. Thirty plants were identified shortly after emergence and monitored throughout the growing season. Percent survival, height, biomass accumulation, and fecundity of the cohorts were determined.

Waterhemp survival and height were averaged over the four locations due to similarity in response to emergence timing and row spacing. There was a 78, 39, 3, and 1% survival rate for the first, second, third and fourth cohorts respectively. Mean height for the first cohort was140 cm, whereas waterhemp emerging at the V8 corn stage were only 13 cm. Row spacing significantly affected height, biomass and fecundity of the first cohort, but later cohorts were not affected by row spacing. For example, biomass of the first cohort was 20% less in 38 cm rows than in 76 cm rows. Biomass and seed production of waterhemp emerging at the V3, V5, and V8 corn stages decreased 80, 97 and 99%, respectively, compared to the first cohort.

FIELD HYBRIDIZATION RATES BETWEEN WATERHEMP AND SMOOTH PIGWEED.
Federico Trucco, Patrick J. Tranel, Mark R. Jeschke, and A. Lane Rayburn, Graduate Student, Assistant Professor, Graduate Student, and Associate Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

The genus *Amaranthus* includes several weedy species of agricultural importance. Several populations of various amaranth species have been documented to be resistant to single or multiple herbicides. Hybridization among amaranths may contribute to their success as weeds and may be a route for resistance transfer among species. Hybrids have been obtained previously from greenhouse crosses with a dioecious amaranth as the female parent and another dioecious or monoecious species as the male parent. However, little has been done to establish the likelihood of hybridization under field conditions or using a monoecious species as the female parent. The purpose of this ongoing study is to determine the frequency of hybridization between smooth pigweed and waterhemp under field conditions. To do this, parents carrying different alleles of the gene encoding acetolactate synthase were used. The male parents were homozygous for a dominant herbicide-resistance allele while female parents were homozygous for a herbicide-sensitive form. Progeny of hybrid nature were thus detected via herbicide selection. The fidelity of the herbicide selection assay was evaluated using both a restriction enzyme polymorphism assay and DNA content analyses. Using these procedures, field hybridization rates between smooth pigweed (female parent) and waterhemp (male parent) as high as 2.7% were detected. Preliminary data suggest that hybrids from the reciprocal cross may occur at about 10-fold higher frequencies.

EFFECT OF NITROGEN ON COMMON WATERHEMP CONTROL IN CORN AND SOYBEAN.

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Nitrogen is considered one of the most important nutrients for the establishment of weeds. Therefore the objective of this research was to evaluate the effect of nitrogen on the control of common waterhemp in corn and soybean. In corn, nitrogen had no effect on common waterhemp population 56 days after planting. However, nitrogen increased common waterhemp population by 8% in soybean. In corn, nitrogen at 100 lb/A increased fresh biomass of common waterhemp by 125%. Nitrogen did not significantly increase fresh biomass of common waterhemp soybean. Nitrogen increased common waterhemp height in corn and soybean. Common waterhemp competition reduced corn height with nitrogen at 0 and 100 lb/A. Common waterhemp competition did not reduce soybean height regardless of nitrogen rate. In corn, there was no difference in common waterhemp control with herbicides applied preemergence regardless of nitrogen rate. Nitrogen reduced common waterhemp control with a postemergence application of mesotrione by 12 to 18%. There was no difference in common waterhemp control in soybean regardless of herbicide application method or nitrogen rate. Common waterhemp competition reduced corn grain yield by 28 to 68% and reduced soybean grain yield by 42 to 69%.

MEASURING THE EFFECTS OF ROTATIONAL TILLAGE SYSTEMS ON POPULATION DYNAMICS IN CORN AND SOYBEANS. Ryan P. Miller, Beverly R. Durgan, and Gregg A. Johnson, Graduate Research Assistant and Professors, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108.

A long-term study of tillage rotations was initiated in the fall of 1998 at the University of Minnesota Southern Research and Outreach Center in Waseca Minnesota. Tillage rotations were implemented over two fields in a corn and soybean rotation. Tillage rotations consisted of continuous chisel plow, continuous strip till, continuous no-till, no-tilled soybeans followed by strip tilled corn, no-tilled soybeans followed by chisel plowed corn, and chisel plowed soybeans followed by strip tilled corn. Tillage operations were performed in the fall, and field cultivation was conducted in spring following all chisel plow treatments. Initial weekly weed assessments were taken in the summer of 2002. The assessments included cataloging weed species, weed species number, average weed heights, weed node or leaf number, and were conducted during the first seven weeks after planting. These assessments were made in permanently established 0.25 meter square quadrates. There were eight quadrates per plot with four located in the inter-row space and four located in the intra-row space. In addition to weekly weed assessments several environmental factors were recorded including: beginning of the season percent residue cover, weekly gravimetric soil moisture, hourly soil temperature, and daily atmospheric weather conditions. Weekly weed assessments are used to analyze weed population dynamics under the different tillage and crop rotations. Results indicate that tillage and crop rotations influence weed population dynamics. Additional studies will determine how tillage rotations will be utilized in an integrated weed management system.

WEED SEEDBANK COMMUNITIES AFTER 35 YEARS OF TILLAGE AND ROTATION. Lynn M. Sosnoskie, John Cardina, and Catherine P. Herms. Department of Horticulture and Crop Science, The Ohio State University, Wooster, OH 44691.

Weed species diversity and community composition of the soil seedbank were characterized 35 years after the implementation of a long-term study involving cropping sequences (continuous corn, corn-soybean, corn-oat-hay) and tillage systems (conventional-, minimum- and no-tillage). Germinable seeds within the top 10 cm of soil in early spring were identified and enumerated in 1997-1999. Canonical discriminant analysis and cluster analysis were used to examine differences in weed community composition with respect to management system. The first canonical function explained 40 to 60% of the within-subjects variation for species composition, for all 3 years. The first canonical function was strongly associated with crop sequence. The canonical scores for the plots planted to corn-oat-hay clustered separately from the continuous corn and corn-soybean plots, and were statistically distinct from them according to Mahalanobis squared distances. There was no similar degree of separation in response to tillage, implying that crop rotation was more important in influencing community composition. Results suggest that weed management and other cultural practices in the corn-oat-hay system favor species with life-history characteristics that differ from species more commonly associated with corn and soybean systems. Crop sequence and tillage system are important non-chemical methods of shifting weed species number and diversity, and therefore, community structure. Manipulation of these factors could help to reduce the negative impact of weeds on crop production.

GLYPHOSATE TOLERANT SUGARBEET: WEED CONTROL, ECONOMICS, AND ENVIRONMENTAL IMPACTS. Andrew R. Kniss, Robert G. Wilson, Alex R. Martin, and Dillon M. Feuz, Graduate Research Assistant, Professor, and Professor, Department of Agronomy and Horticulture, and Associate Professor, Department of Agricultural Economics, University of Nebraska, Scottsbluff, 69391.

Weed control is a costly and necessary part of sugarbeet production, relying heavily on repeated herbicide application, cultivation, and hand labor. The development of sugarbeet tolerant to the broad spectrum herbicide glyphosate through genetic engineering could give growers a more convenient, cost-effective, and environmentally friendly alternative to conventional sugarbeet herbicides. Although several glyphosate tolerant sugarbeet varieties have gained U.S. regulatory approval, they are not currently grown due to lack of sugar company acceptance. The objectives of this research were to compare weed control, economics, and environmental aspects of glyphosate applied to two glyphosate-tolerant sugarbeet varieties to that of conventional herbicide programs applied to near-isogenic non-glyphosate-tolerant conventional varieties. Field experiments were conducted near Scottsbluff, Nebraska in 2001 and 2002. Glyphosate applied two or three times at two-week intervals beginning when weeds were 10 cm tall provided excellent weed control, yield, and net economic return regardless of variety. Three applications phenmedipham plus desmedipham plus triflusulfuron plus clopyralid with or without preemergence ethofumesate provided the greatest weed control among conventional herbicide treatments, but did not always result in the highest yield. One application of glyphosate resulted in yields similar to conventional herbicide treatments. All conventional herbicide treatments resulted in similar net returns. Although the conventional sugarbeet varieties 'HM 1640' and 'Beta 4546' responded similarly to herbicide treatments with respect to sucrose content, 'Beta 4546RR' produced roots with over 1% more sucrose than 'HM 1640RR'. Due to this yield difference a producer planting Beta 4546RR could afford to pay nearly twice as much for glyphosate-tolerant technology as would a producer planting HM 1640RR. When averaged over varieties and herbicide treatments, it is estimated that a producer could afford to pay an additional \$150 ha^{-1} for glyphosate-tolerant technology without decreasing net return. A switch to glyphosate tolerant sugarbeet would result in a modest increase in the amount of postemergence herbicide applied per hectare. However, output from computer modeling programs FIRST and GENEEC suggest that environmental concentrations of glyphosate would be less than those of most conventional sugarbeet herbicides 60 days after application.

MANAGING WEEDS IN SUGARBEET WITH PREEMERGENCE AND POSTEMERGENCE HERBICIDES. Trevor M. Dale, Karen A. Renner, James Stewart, and Lee Hubbell, Graduate Research Assistant and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824; Research Manager, Michigan Sugar Company, Carrollton, MI 48724; and 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/ha + triflusulfuron at 0.004 kg/ha + clopyralid at 0.026 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 proper timing of each 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 in sugarbeet treated with various herbicide programs. Herbicide treatments consisted of a factorial arrangement of five PRE herbicides, including no PRE, cycloate at 3.36 kg/ha, pyrazon 4.48 kg/ha, ethofumesate at 1.68 kg/ha, s-metolachlor at 1.42 kg/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 0.026 kg/ha + 1.5% MSO, desmedipham & phenmedipham & ethofumesate at 0.09 kg/ha + triflusulfuron at 0.004 kg/ha + clopyralid at 0.026 kg/ha + 1.5% MSO. The experimental design was a RCB arranged in a 5 X 5 factorial with four replicates. There were three locations in 2001 and two locations in 2002. PRE only treatments were hand weeded to determine the effect of herbicide only on sugar beet yield and quality.

Common lambsquarters control was 95% or greater in all treatments combined over locations. Cycloate, pyrazon, and ethofumesate increased common lambsquarters and *Amaranthus* control compared to the no PRE treatment. S-metolachlor increased *Amaranthus* control compared to the no PRE treatment. Common lambsquarters and *Amaranthus* control was 95 to 97% among POST treatments. Yields were similar among all treatments. Postemergence treatments applied at the micro-rate or standard-split provided similar weed control and sugarbeet yield when applied after preemergence herbicides. Sugarbeet injury was not affected by preemergence herbicides, and was slightly higher with desmedipham & phenmedipham & ethofumesate at the micro-rate compared to other postemergence treatments.

EFFICACY AND CROP TOLERANCE OF SULFENTRAZONE ON STRAWBERRIES. Rodrigo Figueroa, Douglas Doohan and John Cardina, Graduate Student and Associate Professors, Department of Horticulture and Crop Science, The Ohio State University, Wooster, OH 44691.

Field studies were conducted at Wooster, Ohio (81^{o}58' W longitude, 40^{o}45' N latitude, elevation 310 m) during 2000, 2001 and 2002. Herbicides were applied to strawberries one week after planting. Herbicides included were terbacil and simazine w/wo napropamide, as well as new herbicides reported to be selective on strawberries: pendimethalin, dimethenamid, *S*-metholachlor, ethofumesate and sulfentrazone. Based on 2000 results, sulfentrazone along with flumiclorac, were selected and compared against registered products in 2001. Plant growth evaluations at 1, 3, 6 and 18 weeks after treatment (WAT) shown no significant difference between treated plants, but higher values than hand weeded plants. Plants sprayed with sulfentrazone at the highest rate evaluated (300 g ai/ha) produced similar fruit yield to terbacil treated plants but less plant stunting (1 and 3 WAT). Because of reports indicating pH effect on sulfentrazone activity in other crops, we evaluated this on strawberries in 2002. Data suggest reduced crop tolerance to sulfentrazone when soil pH is above 6.5.

SOIL WEED SEED BANK DYNAMICS IN A TOMATO/SOYBEAN ROTATION. Carlos D. Mayén and Stephen C. Weller, Graduate Research Assistant and Professor, Department of Horticulture, Purdue University, West Lafayette, IN 47906.

A 2 year field experiment was established in Lafayette in the spring of 2001 to investigate the influence of various weed control techniques on the weed soil seed bank in a fresh market tomato (*Solanum esculentum*) and a Roundup Ready soybean (*Glycine max*) rotation. Soil management techniques studied were conventional tillage, no till and winter rye (*Secale cereale*) cover crop. Weed management involved either a threshold based program or a zero threshold program (no weed seed production). Measurements included seeds present in the soil seed bank, weed infestations during the season and crop yield. For both years, there were several similarities and differences. Spring soil samples germinated under greenhouse conditions for both years correlated strongly with actual weed densities in field plots. The weeds present in higher densities were giant foxtail (*Setaria faberi*) and prickly sida (*Sida spinosa*), and later in the season ivyleaf morningglory (*Ipomoea hederaceae*). There were high numbers of common dandelion (*Taraxacum officinale*) present in winter rye plots, for tomatoes and soybeans. This was thought to be related to seed retention of wind blown seeds by standing rye. Weed seed production was lower in threshold soybeans, regardless of the soil management technique, compared to tomatoes. Tomatoes had reduced yields when grown in winter rye. Differences between years included: fewer weeds in tomatoes following soybeans regardless of the previous year weed control intensity, and higher weed numbers in soybean following a threshold based program in tomatoes. Overall, data from both years suggests that there is an important influence of crop rotation, weed control intensity and soil management on the soil weed seed bank and weed populations in the growing season. A soybean crop with good canopy closure and well timed weed control reduced the weed seed returned to the soil, while a tomato crop with only a threshold based weed control allowed high seed deposition in the soil which results in high weed densities the following season. For example, the use of weed thresholds may increase weed densities as much as 4600% and 734% for foxtail and prickly sida respectively.

DIMETHENAMID AS A LAY-BY TREATMENT IN SUGARBEET. Alan G. Dexter and John L. Luecke. Plant Sciences Department, North Dakota State University and the University of Minnesota, Fargo, ND 58105.

Preplant incorporated or preemergence herbicides were used on only 4% of the sugarbeet in eastern North Dakota and Minnesota in 2001. Postemergence herbicides were used on nearly all fields but the postemergence herbicides have little soil residual and weeds that emerge after the last postemergence application frequently are a problem in sugarbeet. Dimethenamid is a soil-applied herbicide with insufficient selectivity in sugarbeet when applied preemergence or preplant incorporated but dimethenamid applied after sugarbeet emergence, or lay-by, is less injurious than preemergence or preplant incorporated dimethenamid and the lay-by treatment will provide control of late-emerging weeds. Experiments were conducted from 1999 to 2002 to determine the most effective time of application and efficacy of dimethenamid used lay-by in sugarbeet.

Dimethenamid-P at 1.65 lb/A gave 76, 31, 18 and 0% sugarbeet injury when applied PPI, POST at the cotyledon to 2-leaf sugarbeet stage, POST at the 2-to 4-leaf stage or POST at the 4-to 8-leaf stage, respectively. Dimethenamid-P at 0.83 or 0.98 lb/A in combination with desmedipham & phenmedipham + triflusulfuron + clopyralid + sethoxydim + methylated seed oil at 0.08 + 0.004 + 0.03 + 0.062 + 1.5% v/v (micro-rate) gave more sugarbeet injury than the micro-rate alone. However, sugarbeet injury was less when the dimethenamid-P was applied in the third (4-to 6-leaf sugarbeet) or fourth (6-to 10-leaf sugarbeet) application of the micro-rate rather than in the first (cotyledon sugarbeet) or second (2-leaf sugarbeet) application.

The micro-rate plus dimethenamid-P, and glufosinate plus dimethenamid-P gave greater control of redroot pigweed than the micro-rate alone or glufosinate alone averaged over several locations. Redroot pigweed control was not improved by dimethenamid-P at locations where the micro-rate alone or glufosinate alone gave nearly complete control. Dimethenamid-P plus glufosinate and s-metolachlor plus glufosinate gave similar sugarbeet injury and similar control of redroot pigweed and common lambsquarters.

DISCOVERY OF A COMMON LAMBSQUARTERS POPULATION RESISTANT TO ALS INHIBITORS IN MICHIGAN. Steven A. Gower and Donald Penner, Academic Specialist and Professor, Diagnostic Services and Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Unacceptable common lambsquarters control was observed in a central Michigan field following at least fourteen consecutive annual applications of an acetolactate synthase (ALS)-inhibiting herbicide. Greenhouse experiments were conducted to (1) determine whether this population of common lambsquarters was resistant to ALS-inhibiting herbicides and (2) determine the magnitude of resistance and cross-resistance to ALS-inhibiting herbicides.

Initial experiments of foliar-applied imazamox and thifensulfuron at 87 and 8.7 g ai ha^{-1} (2X standard field rate), respectively, provided 26 and 19% control of the resistant population compared with 90 and 93% control of a susceptible population, respectively. Atrazine foliar-applied at 4.5 g ai ha^{-1} (2X standard field rate) provided complete control of the resistant population, indicating that this population was susceptible to triazine herbicides.

Comparison of the foliar herbicide rate required to reduce plant fresh and dry weight 50% (GR_{50}) between the resistant and susceptible population was conducted to obtain resistance ratios. Resistance ratios for imazamox were 26 and 27 for fresh and dry weights, respectively. Resistance ratios for thifensulfuron were > 244 and > 355 for fresh and dry weights, respectively. Data indicate resistance in common lambsquarters to both imidazolinone and sulfonylurea herbicides in Michigan.

SUBSTITUTES FOR AMMONIUM SULFATE AS AN ADJUVANT. Donald Penner and Jan Michael, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48823, and Greg Dahl and Joe Gednalske, Agriliance, LLC. Inver Grove Heights, MN 55077.

Glyphosate and glufosinate are examples of weak acid herbicides whose maximum efficacy is dependent on the inclusion of ammonium sulfate or other effective "water conditioner" adjuvants in the spray solution. The source of ammonium sulfate is often the dry diammonium sulfate. Liquid formulations of diammonium sulfate are available as many applicators prefer liquid to dry sources. The objectives of this research was to evaluate substitutes for ammonium sulfate for use with various formulations of glyphosate recognizing weed species specific responses to the need for ammonium sulfate or substitutes with glyphosate. Greenhouse studies showed a greater need for ammonium sulfate with glyphosate for velvetleaf and giant foxtail control than for common lambsquarters control. The ammonium sulfate substitute, 'Exacto 390', at 0.63 to 0.75% in the spray solution was found to be an effective substitute for ammonium sulfate with several formulations of glyphosate for weed control without injury to glyphosate-resistant corn or soybean. In field trials in 2002 the 'Exacto 390' showed efficacy similar to effective levels of the liquid ammonium sulfate containing products, 'N Pak AMS', 'Class Act Next Generation', and 'Alliance'.

A SECOND TRIAZINE RESISTANCE MECHANISM IN WATERHEMP. Patrick J. Tranel, William L. Patzoldt, Bradley S. Dixon, and Dean E. Riechers, Assistant Professor, Graduate Research Assistant, Undergraduate Research Assistant, and Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Resistance to triazine herbicides is well documented, and is usually due to an altered herbicide site of action (D1 protein). Because the gene encoding the D1 protein is encoded in chloroplasts, target-site triazine resistance is maternally inherited. Recently, we identified waterhemp (*Amaranthus rudis* and *A. tuberculatus*) populations with atrazine resistance that did not appear to be maternally inherited. Specifically, atrazine resistance was observed to segregate among half-sib families that each had a common female parent. Therefore, research was conducted to verify the novel atrazine resistance in waterhemp and to begin charactering it.

Three waterhemp populations where included in the study: SegR, a population segregating for atrazine resistance and suspected of having the new resistance mechanism; UniR, a population uniformly resistant to atrazine and suspected of having target-site resistance; and UniS, a uniformly atrazine-sensitive population. Sequencing of a fragment of the gene encoding the D1 protein revealed that UniR plants contained the point mutation typically found in triazine-resistant plants. No sequence differences were identified when the gene was compared among atrazine-resistant and atrazine-sensitive plants of the SegR population and plants from the UniS population. Results from chlorophyll fluorescence assays provided further confirmation that atrazine resistance was target-site mediated in UniR plants, but not in SegR plants. SegR plants exhibited modest recovery of electron transport perturbation over a period of four days after atrazine treatment, suggesting resistance was due to atrazine metabolism.

Crossing experiments were conducted to begin to understand the inheritance of the new resistance mechanism. Progeny from a SegR by UniS cross, and from the reciprocal cross, could be classified as having one of three atrazine-response phenotypes: sensitive, resistant, or intermediate. Progeny from a SegR by SegR cross also grouped within these classifications. Because sensitive plants were recovered from the SegR by SegR cross, resistance must not have been fixed in the parents, even though only resistant plants were used for the parents. Heterozygosity in the SegR parents complicated analysis of the SegR by UniS crosses; however, resistance must have been nuclear transmitted, since resistant progeny were recovered from both of the two reciprocal crosses.

Our current hypothesis is that the newfound triazine resistance is mediated by enhanced herbicide metabolism, and is controlled by two or more genes. Although preliminary, results from experiments using tridiphane to overcome atrazine resistance indicated that resistance is not primarily mediated by glutathione-S-transferases.

POTENTIAL FOR SELECTION OF GLYPHOSATE RESISTANCE IN *AMARANTHUS TUBERCULATUS* (MQ. EX DC) J.D. SAUER). Ian A. Zelaya and Micheal D.K. Owen, Graduate Research Assistant and Professor, Department of Agronomy, Iowa State University, Ames, IA 50011.

Despite the prolonged use of glyphosate worldwide, the evolution of resistance in weeds is an uncommon event. The low probability for resistance may be attributed to the limited metabolism of glyphosate in plants, the short-half life in the environment and unique biochemical characteristics of the herbicide. Some reported cases of resistant weeds evolved after prolonged selection pressure by glyphosate, thus suggesting that the frequency of resistant individuals within the populations are extremely low or that the event causes a physiological penalty to the plant. Point mutations in 3-phosphoshikimate 1-carboxyvinyltransferase (EPSPS; 2.5.1.19) associated with an increased dissociation constant for glyphosate ($K_i^{glyphosate}$), can result in a loss of kinetic efficiency of the enzyme.

One species resistant to glyphosate has been reported to date in the US. However, the adoption of glyphosate resistant crops may increase the selection pressure and isolate genotypes with an increased fitness to glyphosate. Midwest producers have reported inconsistent control of *Amaranthus tuberculatus* (Mq. ex DC) J.D. Sauer with glyphosate in glyphosate-resistant crops. Investigation of reports in Everly and Badger, Iowa suggested that *A. tuberculatus* plants were differentially affected by glyphosate. Plant and seed samples were collected at the Everly location to assess the potential for selection of glyphosate resistance.

Comparisons of the Everly, Iowa *A. tuberculatus* and a pristine population from Paint Creek, Ohio suggested that the Everly biotype was more variable to glyphosate than the unselected material. Thus, the Everly population was subjected to a divergent recurrent selection, where resistant and susceptible plants were identified though a seedling assay. Shikimic acid determinations and seedling and whole plants dose responses were performed after every cycle of selection. This approach resulted in a 1.7 and 3.5 fold increase in population divergence in the first (F1) and second (F2) filial generations, respectively. However, significant segregation for glyphosate efficacy was still apparent in the selected material. While the selection method has increased the frequency of resistant individuals within the population, no homozygous-stable lines have been isolated. This limited segregation suggested that the response to glyphosate observed in *A. tuberculatus* may be determined by a polygenic event or incomplete dominance. A single nuclear gene inherited in an incompletely-dominant manner is associated with glyphosate resistance in *Lolium rigidum* Gaudin. Other reported cases of glyphosate resistance required several years and cycles of selection to evolve. We speculate that resistance will evolve in *A. tuberculatus* if similar selection pressures are enforced on the populations.

Presently, we are attempting to reduce the genotypic variability through a three-level selection scheme where plants are characterized by their response to glyphosate at the seedling and whole-plant levels and confirmed by their shikimic acid accumulation pattern. We plan to investigate possible resistance mechanism in asexually-propagated resistant, susceptible, and pristine *A. tuberculatus* plantlets. Methods have been optimized to assess *in vivo* differences in absorption and translocation of glyphosate and degradation to the major metabolite α-aminomethylphosphonic acid (AMPA). In addition, attempts will be made to sequence *EPSPS* and determine whether polymorphism of the gene is associated with the observed phenotype. We constructed an *EPSPS* contig from 25 genes from 14 plant species and identified four regions of nucleotide conservation suitable for primer development. Genomic DNA was amplified by polymerase chain reaction (PCR) and products cloned in a vector for direct nucleotide sequencing. This approach enabled cloning a 798 bp fragment with 78% and 92% homology at the nucleotide and amino acid levels to the canola (*Brassica napus* L.) *EPSPS*, respectively. This putative *A. tuberculatus EPSPS* fragment lies at position 1795 and encompasses introns #4 and #5 of *B. napus EPSPS*. Characterization of the mechanism(s) of glyphosate resistance may be important in developing strategies to mitigate potential future problems.

MOLECULAR BASIS FOR GLYPHOSATE RESISTANT RIGID RYEGRASS (*Lolium Rigidum* Gaud.). Marulak Simarmata, John E. Kaufmann, and Donald Penner, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48823.

Rigid ryegrass plants collected in California in 1998 varied in resistance from one to 1-10 times the rate of glyphosate necessary to kill the susceptible plants. Selection has continued through the 4th and 6th generations for the susceptible (S) and resistant (R) biotypes, respectively. The resistant biotype was phenotypically identical to rigid ryegrass, whereas the sensitive biotype was phenotypically similar to annual ryegrass (*Lolium multiflorum*). The basis for glyphosate resistance of rigid ryegrass has not been elucidated. Results of previous studies showed that absorption, translocation, and metabolism could not explain the basis of glyphosate resistance in rigid ryegrass. Also intercellular movement of glyphosate into the chloroplast could not be distinguished between R and S biotypes. The objectives of this study were to determine if there were differences in the EPSP synthase gene between R and S biotypes, and to study the inheritance of glyphosate resistance in rigid ryegrass. Forward and reverse primers were designed based on the EPSP gene of *Lolium rigidum* (published by NCBI AF349754). Amplified DNA fragments from both biotypes were visualized under the UV light. The sequences of the amplified fragments were longer than expected from the published sequence. There were 93 and 88 base pairs in the DNA insertion for R and S biotypes, respectively. The differences in the insertions between R and S genes may play an important molecular role in glyphosate resistance. The inheritance of glyphosate resistant rigid ryegrass was evaluated by crossing the R biotype with a known sensitive ryegrass variety. F2 plants generated from F1 were evaluated for sensitivity to glyphosate. The ratio of susceptible, intermediate, and resistance base on arbitrary rates of glyphosate indicated that inheritance of glyphosate resistance in rigid ryegrass involved more than one gene.

AN ILLINOIS WATERHEMP BIOTYPE WITH RESISTANCE TO PPO, ALS, AND PSII INHIBITORS. William L. Patzoldt, Aaron G. Hager, and Patrick J. Tranel, Graduate Research Assistant, Assistant Professor, and Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

A waterhemp population was identified in Adams County, Illinois, that was not controlled following a postemergence treatment of lactofen, a protoporphyrinogen oxidase (PPO)-inhibiting herbicide. Greenhouse studies were conducted to characterize waterhemp responses to lactofen and various other herbicide mode-of-action chemistries when compared to a sensitive population. The Adams County population was 19-fold resistant to lactofen when compared to the sensitive population. The Adams County population was about 16,000-fold and 9,000-fold resistant to imazamox and thifensulfuron, respectively, two acetolactate synthase (ALS)-inhibiting herbicides. Sequencing of *ALS* from resistant plants identified a tryptophan to leucine substitution at amino acid position 574 of ALS conferring resistance. In response to the photosystem II (PSII) inhibitor atrazine, the Adams County population was 25-fold resistant. Chlorophyll fluorescence measurements of intact leaves following a foliar treatment of atrazine suggested that an altered target site was not the mechanism of resistance. Waterhemp plants within the Adams County population survived treatment with a solution containing lactofen at 175 g ai ha^{-1}, imazamox at 44 g ae ha^{-1}, and atrazine at 1000 g ai ha^{-1} plus 1% COC and 2.5% AMS. A treatment solution containing the equivalent rate of any one of these herbicides gave acceptable control of waterhemp from the sensitive population. Contrary to results obtained with previously mentioned herbicides, the Adams County population was not resistant to glyphosate or paraquat.

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

A biotype of common waterhemp (*Amaranthus rudis*) difficult to control with PPO inhibiting herbicides was reported near Sabetha, KS in 2000. Greenhouse experiments confirmed resistance to protox-inhibiting herbicides as well as acetolactate synthase-inhibiting herbicides. The objectives of this study were to determine if absorption, translocation, and metabolism is the basis for protox-resistance in common waterhemp. At 13 to 18 cm tall, susceptible (S) and resistant (R) common waterhemp plants were treated with ^{14}C labled acifluorfen or lactofen. Six, 12, 24, and 72 h after herbicide application, plants were divided into treated leaf, foliage above treated leaf, foliage below treated leaf, and roots. Absorption increased as harvest time increased, however, absorption was similar for both biotypes and herbicides. For both biotypes, 85-95% of acifluorfen and lactofen remained in the treated leaf. An organophosphate insecticide interaction experiment was also conducted to determine if cytochrome P450 was involved in the mechanism for resistance. Resistant plants were treated with a recommended rate of malathon or diazinon followed by a 1x rate of acifluorfen or lactofen. Acifluorfen and lactofen rates required to induce 50% visible injury were not different when herbicides were applied alone and with an insecticide. Because the R and S biotypes had similar acifluorfen and lactofen absorptions and translocations, the mechanism of resistance is not due to insufficient absorption or translocation. Also, results indicate no cytochrome P450 metabolism of acifluorfen or lactofen in the R biotype.

GLUTAMINE SYNTHETASE AND AMMONIA ACCUMULATION IN RESPONSE TO TIME OF GLUFOSINATE APPLICATION. Brent A. Sellers and Reid J. Smeda, Graduate Research Assistant and Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211.

Previous research has shown that time of glufosinate application has a large impact on weed control. This is espcecially true for weeds that exhibit diurnal leaf movements such as velvetleaf. Velvetleaf leaf angle has been shown to negatively impact glufosinate efficacy. However, leaf angle is not the sole reason for reduced glufosinate efficacy when applications are made near or after sundown. In addition to leaf angle, a physiological mechanism may account for reduced glufosinate efficacy. Glutamine synthetase (GS) activity has been shown to sharply decline within 5 h of application, and results in an increase in ammonia accumulation. Experiments were established to determine if GS activity and ammonia accumulation were dependent upon the time of glufosinate application. Plants were established in pine seedling containers in a sand:peatmoss (1:1) soil mixture with a 14 h light period ending at 8 pm. Velvetleaf seedlings were thinned to one plant per container at the cotyledon stage. Plants were watered and fertilized to optimize growth, and were transferred to a growth chamber 3 d prior to glufosinate application. Growth chamber conditions were 26 C with 80-90% RH and 230 μmoles/s/m^2. A track sprayer, calibrated to deliver 187 L/ha at 167 kPa, was used to apply glufosinate at 160 or 320 g ai/ha to 10 cm tall plants at 2 and 10 pm. Leaf angles were fixed using pipe cleaners. Glutamine synthetase acitivity and ammonia accumulation were determined 0 to 72 hours after treatment (HAT). Velvetleaf GS activity for plants treated at 2 pm, regardless of rate, was reduced to less than 20% compared to 0 h control plants within 8 HAT. In contrast, GS activity following 10 pm applications did not decline below 20% until after 24 HAT for both rates. GS activity was not significantly different between application times for either rate at or after 48 HAT. Ammonia accumulation, regardless of rate, increased throughout the experiment, after applications at 2 pm, and after an 8 h lag after applications at 10 pm. Ammonia accumulation was signicantly higher by 72 HAT when 160 g/ha glufosinate was applied at 2 pm compared to applications at 10 pm. There were no differences in ammonia accumulation between application times at the 320 g/ha rate, except at 4, 8 and 24 HAT. Ammonia accumulation may explain why reduced activity resulting from late-day applications may be overcome by increasing the herbicide rate. At lower herbicide rates, ammonia accumulation does not increase to the same extent for glufosinate applied at 10 pm versus 2 pm, even though GS activity is severely inhibited. It is possible that glutamate dehydrogenase, another enzyme capable of incorporating ammonia, is responsible for the reduction in ammonia accumulation in 10 pm treated plants. This will be investigated in future experiments.

IMPLICATIONS OF THE GENE GDHA FOR HERBICIDE TOLERANCE IN PLANTS. Scott A. Nolte, Bryan G. Young and David A. Lightfoot, Graduate Research Assistant, Assistant Professor and Professor, Department of Plant, Soil, and General Agriculture, Southern Illinois University, Carbondale, IL 62901.

Plants convert inorganic nitrogen into organic compounds through the process of ammonium assimilation. This occurs in plants by two possible pathways. The first and primary pathway involves a reaction with glutamate to form glutamine which is catalyzed by glutamine synthetase (GS) and requires an energy source of adenosine triphosphate. This glutamine is then involved in a reaction catalyzed by glutamate synthase (GOGAT) to form glutamate. The second pathway also results in the formation of glutamate through a reaction catalyzed by glutamate dehydrogenase (GDH), but does not have the energy requirement. An isolated *gdh*A gene from *E.coli* which encodes for a more active GDH pathway was used to transform plants which resulted in an increase in ammonia detoxification. The proposed mode of action of the herbicide glufosinate is to block the GS pathway, thereby causing ammonia toxicity in the susceptible plants. Therefore, it was speculated that the *gdh*A transformed plants may exhibit a novel mechanism of tolerance to glufosinate by detoxifying ammonia via greater activity of the GDH pathway.

Studies were conducted in the greenhouse to evaluate tolerance of tobacco containing the *gdh*A gene to glufosinate on a whole plant level. Six tobacco lines were selected including a commercial variety, a non-transformed control, three transformed lines with varying levels of expression of the gene *gdh*A, and one transformed with the bialaphos resistance (bar) gene, isolated from *Streptomyces hygroscopicus*. These lines were subjected to 10 rates of glufosinate ranging from 1/256 to 256X of the recommended field use rate of 351g ai/ha and then evaluated for herbicide efficacy. Comparisons of dry weights revealed that transformed plants were expressing tolerance to glufosinate. Upon further analysis, the level of expression of the *gdh*A gene was found to be highly correlated (r = 0.9903) to the level of herbicide tolerance. At the highest level of gene expression the *gdh*A transformed plants exhibited a 6X greater tolerance to gulfosinate than the non-transformed control plants. Thus, this research demonstrated the use of the *E. coli gdh*A gene in plant transformations can indeed produce a plant that has a novel mechanism for tolerance to glufosinate.

FIELD AND WIND TUNNEL EVALUATIONS OF DRIFT REDUCTION NOZZLES AND AGENTS FOR GLYPHOSATE APPLICATIONS. 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.

Field and wind tunnel studies were conducted in 2001 and 2002 to evaluate the performance of drift reduction nozzle and agent combinations for applications of glyphosate. Glyphosate was applied at 210 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 0.05 and 0.1 ml ai/L and 300 and 600 mg ai/L, respectively. Each treatment was applied using one of four 110015 nozzle types [XR TeeJet(XR), Turbo TeeJet(TT), AI TeeJet(AI), and DG TeeJet(DG)]. Treatments were applied in a water carrier at 94 L/ha. In field studies, water-sensitive cards were placed in each plot to collect droplet data. Similarly, water-sensitive cards were used to collect droplet data at a distance of 4 m downwind from the nozzle in the wind tunnel studies. DropletScan software was used to analyze all cards in terms of coverage, number of droplets collected, and volume median diameter (VMD).

In field evaluations, nozzle type, agent type and rate, and combinations of each increased VMD, while reducing both coverage and droplet counts. Drift reduction nozzles increased VMD compared to XR nozzles, with increases ranging from 30 µm with DG nozzles to 144 µm with AI nozzles. Similarly, VMD was increased as the rate of either PA or HPG increased. All treatments with drift reduction nozzles reduced droplet counts compared to the standard treatment of XR nozzles with no agent. Treatments with DG and TT nozzles reduced the number of droplets collected by at least 2,390 droplets regardless of agent rate, while treatments with AI nozzles reduced droplet counts by no less than 5,500 droplets. Coverage was reduced by 5 to 14% with the use of a drift reduction nozzle type compared to treatments with XR nozzles, and by 3 to 6% with half and full rates of an agent, respectively.

In wind tunnel evaluations, physical spray drift, coverage, and droplet counts were all reduced with combinations of drift reduction nozzles and agents. Total drift was reduced by up to 42% for all treatments applied through DG and AI nozzles. The amount of drift was also reduced by 13 to 18% with the use of a full rate of either PA or HPG, respectively, in combination with XR nozzles. All drift reduction nozzle types when used in combination with a full rate of either type of agent reduced both coverage and droplet counts relative to the standard treatment of XR nozzles and no agent.

USING HYPERSPECTRAL IMAGERY FOR DETECTION OF HERBICIDE INJURY IN SOYBEANS. David J. Alderks, Christy L. Sprague, Donald G. Bullock and Loyd M. Wax. Graduate Research Assistant, Assistant Professor and Professor, Department of Crop Science, USDA-ARS, University of Illinois, Urbana, IL 61801.

Herbicide injury on soybeans from spray drift, misapplication, or tank contamination of corn herbicides can be a major problem. There is very little information available on what effect mesotrione, a recently registered corn herbicide, has on soybean if exposure occurs and if this injury can be detected through the use of remote sensing. In 2001 and 2002, research was conducted examining soybean responses from simulated mesotrione drift and if this information could be correlated to hyperspectral imagery taken of the plots. Mesotrione rates ranged from the full labeled use rate of 105 g/ha down to 1/256X of the full labeled rate. In 2002, additional treatments included the addition of atrazine at 280 g/ha for the 1X rate. Atrazine rates decreased incrementally with the mesotrione rates. Soybean injury was examined 7, 14 and 28 days after treatment (DAT). Hyperspectral images where also taken at these times. A multivariate analysis was preformed with the imagery data. The principal component analysis indicated that principal component one explained greater than 90% of the variability. Principal components and a calculated normalized difference vegetation index (NDVI) were correlated with visual injury and soybean yield. Significant soybean injury was observed starting at the 1/32X rate and 1/16X rate of mesotrione in 2001 and 2002, respectively. Significant yield reductions started at the ¼X rate in both years. Correlations of the hyperspectral imagery with soybean injury and yield were 0.97 and -0.61 in 2001 and 0.92 and -0.87 in 2002, respectively. NDVI calculations indicated that not all hyperspectral bands were needed for injury detection.

EFFECT OF POST EMERGENCE HERBICIDE ON THE REFLECTANCE RESPONSE PATTERNS OF CORN. 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

To increase the ease of research being conducted in site-specific weed management and weed species identification via remote sensing, the impacts of herbicides on corn reflectance response patterns are being researched. It may be possible to find reflectance response patterns of individual weed species that would open the future to a broad expanse of possibilities in these fields. The identification of herbicides that do not impact the spectral response pattern of corn 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 costs required to study reflectance response patterns of weed/crop population dynamics.

Experiments were conducted at the Agronomy Research Center near West Lafayette, IN. POST corn herbicide treatments evaluated were 1.7 kg a.i./ha atrazine + .95 L/ha COC, 560 g a.i./ha bromoxynil + 1% v/v COC, 798 g a.i./ha. 2,4-D, 212 g a.i./ha dicamba + 83 g a.i./ha diflufenzopyr + 0.25% v/v NIS, 70 g a.i./ha nicosulfuron + 1% v/v COC, and 40 g a.i./ha primisulfuron-methyl + 0.25% v/v NIS. The herbicides were selected to represent the chemicals used in the Midwest. Treatments were also selected to have varying modes of action that can result in various symptoms on the corn plants. This range of symptomology has the potential to create a broad range of plant reflectance response patterns.

Multispectral aerial images composed of three bands of reflectance were collected over the test areas from 3 to 8 weeks after herbicide application, 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 2 weeks after application. 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.

SAS PROC STEPDISC and PROC DISCRIM were used to identify and model up to twelve bands of reflectance from the data most useful for differentiating between individual herbicide treatments and untreated plots and the Fisher linear discriminant classifier in MultiSpec was used to classify treated plots in pair-wise comparisons with the untreated plots. Results show POST herbicide treatments atrazine and primisulfuron-methyl have little or no impact on the spectral reflectance of corn and would be well suited for research areas that require no spectral change after application. 2,4-D and dicamba + diflufenzopyr were found to have an effect on the spectral properties of corn when using both multispectral and hyperspectral data. In situations where spectral reflectance change is not desired, neither 2,4-D nor dicamba + diflufenzopyr should be used. These herbicides have high potential to change the spectral reflectance properties of corn. Through further characterization of wavelengths to distinguish 2,4-D and improved classification procedures, areas treated with 2,4-D could be identified and potentially be used for research, commercial applications, or insurance purposes.

COMPARISON OF VENTURI SPRAY TIPS AND SPRAY PRESSURES ON GLYPHOSATE AND PARAQUAT EFFICACY. Robert E. Wolf, Cathy L. Minihan and Dallas E. Peterson, Extension Specialist, Biological and Agricultural Engineering, Assistant Scientist and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

This study was designed to measure herbicide efficacy and droplet characteristics using three venture style tips at three different operating spray pressures. Venturi style tips including air induction (AI) from Spraying Systems, air mix (AM) from Greenleaf, and ultra lo-drift (ULD) from Hypro were compared to the turbo flat-fan (TT), also from Spraying Systems. The four tips were compared at spray pressures of 207, 345, and 482 kPa with a spray volume of 94 L/ha. The nozzle angle and orifice size used in all treatments was 11002. To maintain the target application volume, the application speed was altered at the different pressures. The applications were made with a tractor plot-sprayer equipped with a 3 m rear mounted boom. Nozzles were spaced at 76 cm, located 51 cm above the target, and were tilted with a rearward incline of 15 degrees. Glyphosate and paraquat were used to compare efficacy on velvetleaf, common sunflower, sorghum and corn. The study was comprised of 24 treatments with three replications. In addition to efficacy ratings, water sensitive cards were placed under the spray boom to collect the droplet data. Two cards per treatment over two replications were summarized representing 96 cards. DropletScan software was used to analyze the cards and SAS was used to separate difference in means.

Efficacy ratings show that very few interactions were significant among herbicide, tip and spray pressure variables. Species control varied between glyphosate and paraquat as would be expected. Paraquat provided better velvetleaf control, glyhosate gave better sorghum and corn control, and common sunflower was similar for the two herbicides.

Only minor differences in control occurred among spray tips or spray pressures. Weed control was or tended to be slightly lower with the turbo flat-fan than the venture style tips. The difference in control was greatest for the velvetleaf, but still was less than 10 percent. Among the venture tips, AI and AM tips tended to give slightly better weed control than the ULD tips. However, the differences were small and usually not significant. No significant differences in weed control occurred among the three pressures.

The droplet statistics volume median diameter (VMD, 50%), actual GPA collected, percent area coverage, and droplets less that 200 microns were measured from the water sensitive cards for each tip. The VMD means for the AI, ULD, AM, and TT was 625, 582, 571, and 549 microns respectively. The AI had a significantly larger micron size that the AM and TT. None of the other comparisons for VMD were significant. Significant differences were also measured for percent area coverage among the chemical, tip and pressure interactions. Percent area coverage means ranged from 47 to 20 percent. Differences among treatments separated by at least 11.5 percent were significant. An important statistic for indicating drift potential is the number of droplets that are 200 microns or less in size. No significant differences were found for this statistic. Also, no significant difference in collected GPA was found.

As evidenced in this study, very few significant differences were found among treatments. One plausible explanation for reduced control with the turbo flat-fan tip may be that high temperature and low humidity conditions were present when the trial was sprayed. The smaller drops produced compared to the venture style tips may have been subjected to evaporation or faster drying. Overall, these results suggest that equal or better weed control can be achieved with the new venture style tips compared to the turbo flat-fan tips, regardless of whether a systemic or contact herbicide is being applied. All tips can also be used within a pressure range of 207 to 482 kPa while maintaining a similar level of performance. Performance over a wide range of pressure is important with the use of spray controllers that maintain spray volumes over speed changes that result in pressure adjustments. Venturi tips appear to be a viable option to minimize spray drift potential and maximize performance.

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USING *WEEDCAST* COMPUTER MODEL TO DETERMINE POTATO CULTIVATION TIMING.

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WeedCast computer model was evaluated as a decision aid to determine cultivation time in potatoes at Wooster, OH, Fargo, ND, and Charlottetown, PE, Canada in 2001 and 2002. Split-plot design with cultivation time as the main plots and +/- herbicides as subplots was used. Main plots were cultivated when the model predicted 15, 30, or 60% weed emergence for the most predominant species on the site. Subplots were either treated with metolachlor + metribuzin at 1.68 and 0.5 kg ai/ha, respectively, or left unsprayed. Subplots within the control were weeded only at layby. Otherwise, potatoes were grown using standard cultural practices as recommended by the respective extension services. Cultivation timing was predicted using pigweeds (*Amaranthus* spp) and Pennsylvania smartweed *Polygonum pensylvanicum* in 2001 and 2002, respectively, at Wooster and common lambsquarters (*Chenopodium album*) at Charlottetown. Eastern Black nightshade (*Solanum ptychanthum*) was the indicator at Fargo in 2002. Weed control for the different cultivation timings varied between years. Overall, plots treated with herbicides had lower numbers of weeds m^{-2} at Wooster and Charlottetown in 2001. Cultivation timing based in 15% predicted emergence of *Amaranthus* spp and *C. album* resulted in better weed control and higher tuber yield at Wooster and Charlottetown, respectively, in 2001. In 2002, however, 30% emergence of *P. pensylvanicum* was the best predictor. Weed pressure was high in the cultivation only plots regardless of cultivation timing. *Amaranthus* spp density was 12 to 184 weeds m^{-2} for cultivation only plots at 5 wk after hilling, compared to only 0 to 4 weeds m^{-2} for herbicide treated plots. There was no apparent pattern for treatment effects at the Fargo site in 2002, but cultivation alone at 30% predicted *S. ptychanthum* emergence provided the best suppression of *Amaranthus retroflexus*. At Charlottetown in 2002, visual observations indicate that the 15% predicted emergence of *C. album* timing resulted in best weed control with successively later cultivation giving poorer results. The study will be repeated in 2003 to confirm the results.

THE LONG TERM IMPACT OF INTERACTIONS OF ATRAZINE RATES, TILLAGE LEVELS AND COVER CROPS ON WEED SEED SOIL BANKS. Randall S. Currie, Associate Professor, Southwest Research-Extension Center, Kansas State University, 4500 East Mary Street, Garden City, KS 67846.

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, 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 1.1-kg/ha applications of glyphosate. In the spring of 2002, glyphosate-resistant corn was planted and bi-weekly weed counts followed by a 1.1-kg/ha application of glyphosate were continued until corn was too tall to spray. Even 22 months after a single tillage event followed by a “perfect” rotational “crop”, fallow, and “perfect” postemergence control, tillage more than doubled the number and height of *Palmer amaranth*, that emerged after the corn was too tall to spray, and more than tripled their bio-mass per acre. Further, 27 months after killing a wheat cover crop under these “perfect” conditions, it also reduced the height of *Palmer amaranth* that emerged after the corn was too tall to spray, 2 fold and its biomass 3 fold. Therefore, we conclude that, surface residue has a dramatic and long lasting positive effect on weed control.

RISKS OF WEED SPECTRUM SHIFTS AND HERBICIDE RESISTANCE IN GLYPHOSATE TOLERANT CROPPING SYSTEMS. Robert G. Wilson, Professor, Department of Agronomy and Horticulture, University of Nebraska, Scottsbluff, NE 69361.

Experiments were conducted in the field from 1998 through 2002 to determine if glyphosate use patterns in glyphosate tolerant cropping systems influenced weed control by placing selection pressure on weed species, altered weed population dynamics, or lead to the development of glyphosate-resistant weeds. Experiments were designed as a two factorial split plot set in a randomized complete block design with four replications. Main plots were either continuous glyphosate tolerant corn or a rotation of glyphosate tolerant corn, sugarbeet, corn, sugarbeet, and wheat. Sub-plots were glyphosate at 0.4 kg ha^{-1} applied twice, glyphosate at 0.8 hg ha^{-1} applied twice, a rotation of glyphosate at 0.8 kg ha^{-1} applied twice followed the next year by a non-glyphosate treatment, or a non-glyphosate treatment each year. The seed bank was examined each year before crop planting. Weed density was measured before herbicide treatment, 2 wk after the last herbicide treatment, and at crop harvest. During the course of the experiment no weeds were observed to develop resistance to glyphosate. Over the five year period the weed population shifted from a kochia and wild proso millet dominated population to a predominately narrowleaf lambsquarters population. Narrowleaf lambsquarters seed and plant populations increased in areas treated with the low rate of glyphosate but decreased in areas treated with the high rate of glyphosate. Green foxtail and longspine sandbur increased in non-glyphosate treated areas. Narrowleaf lambsquarters increased to a greater extent in the corn-sugarbeet rotation compared to continuous corn. Kochia and hairy nightshade were more prevalent in continuous corn than in the corn-sugarbeet rotation.

HOW WEED COMMUNITIES RESPOND TO CHANGING ENVIRONMENTS. J. Anita Dille, Assistant Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

The phenomenon of weed community shifts is expected and inevitable. A community is an assemblage of species populations, which occur together in space and time. A shift would occur when the assemblage changes. The environment and its numerous constraints structure a plant community. These constraints are impacted and changed in significant ways by our activities as humans. Available resources, such as N, P, K, S, water, light, and others, are limited. Appearance of new species in a community is limited by lack of dispersal and recruitment. The presence of predators and pathogens also restrict establishment of new species. Disturbance removes the current vegetation and opens up gaps for new species to arrive, and includes fire, windstorms, grazing and hooves, tillage and chemical applications. Plants have optimal growth conditions and competitive abilities at particular temperatures and thus, in particular climates. Plants respond to mean levels of limiting factors as well as to extent and patterning of fluctuations in time. In total, a large number of environmental factors and processes limit the abundance of species populations in communities. Weed communities respond to these environmental constraints through ecological principles of biodiversity, selection and succession. Biodiversity can be characterized by the number of different weed species present, the genetic and phenotypic variation within a species, and by the development of unique biotypes of a given weed species. Both natural and artificial selection pressures influence community shifts when examined from a long-term to short-term perspective. Selection acts on individuals within a population that occur within a community. Successful selection results in that individual surviving, reproducing, and leaving descendants in a given environment and not in another. Thus, there is the potential for a shift in genotype and weed species over time. Succession is the non-season, directional and continuous pattern of colonization and extinction on a site by species populations. As disturbance is reduced, species populations adjust to the new environment created and in the example of old field succession we observe shifts from annuals to herbaceous perennials to shrubs and woody species. There are several methods to document weed community shifts. For example, the use of general surveys of weed species populations in a field over many years or specific surveys in response to imposing different environmental constraints would allow us to document changes. Diversity of a weed community can be measured using diversity indices in order to document dominant and rare species occurrences. With information about weed characteristics and changes in environmental constraints, and understanding historical shifts that have been observed, it may be possible to model and predict future weed community shifts.

The speakers in the “Weed Community Shifts” symposium: Doug Buhler, David Heering and Frank Forcella, will provide rationale, examples, and proposed reasons for observing shifts in weed communities in response to changing tillage practices, choices of weed management practices, and in glyphosate-tolerant soybean cropping systems.

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TILLAGE PRACTICES, WEED SEED BANKS, AND WEED COMMUNITY DYNAMICS. Douglas D. Buhler, Professor and Chair, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

The composition of weed communities of arable land is largely a reflection of agronomic practices. Reducing tillage in crop production changes the environment where weeds are managed, survive, and reproduce. The shift from tillage systems that include extensive annual soil disturbance to systems that minimize soil disturbance will cause major changes in weed population dynamics. While results have varied among experiments, some general trends in weed population dynamics in conservation tillage systems have arisen. These include increased populations of perennial, summer annual grass, biennial, and winter annual species. Densities of large-seeded dicot species often decrease with decreasing tillage. The ecological and management aspects of these changes are varied and complex. Effective, economical, and environmentally sound weed management in conservation tillage systems over the long-term will require integration of new information with established principles of weed management. New technologies must be developed to deal with the altered ecosystems created by conservation tillage production systems. Current knowledge indicates that many weed species and weed control tactics behave differently as tillage is reduced or eliminated. These changes must be taken into consideration to develop economically and environmentally sound weed management systems.

WEED ESCAPES AND DIVERSITY IN GLYPHOSATE-TOLERANT SOYBEAN: TRENDS ALONG A TRANSECT FROM MINNESOTA TO LOUISIANA. Frank Forcella, Research Agronomist, USDA-ARS, Morris, MN 56267.

Objectives of this study were to examine the number and diversity of weed escapes, as well as soybean yields, along a latitudinal transect in glyphosate-tolerant soybean systems. An additional aim was to determine mechanisms that allowed certain species to escape control by glyphosate. Data were collected in 2001 and 2002 from established weed management trials at 12 experiment stations along a north-south gradient throughout the central USA. The states (and number of sites) included Minnesota (4), Iowa (3), Missouri (2), Arkansas (2), and Louisiana (1). Yield and weed diversity data were collected from the following herbicide treatments: One-Pass Glyphosate, Two-Pass Glyphosate, Standard PRE + Glyphosate, Standard PRE only or PRE + Standard POST or Standard POST only, and Weedy Check. Field methods and calculations included yield samples, density recorded by species, percent cover recorded by species, effective species richness (e^H'), 3 to 4 plots per treatment, and field sampling in autumn. At the Minnesota sites, permanent quadrats were monitored in weedy check treatments to determine patterns of seedling emergence. Seeds of plants that escaped control in glyphosate-treated plots were collected, as were those from weedy check plots. These seeds were germinated in pots, the seedlings exposed to a dilute rate of glyphosate in a spray cabinet, and assessed two weeks later. For crop yields, no latitudinal trends for weedy checks were apparent, possible slight decreases in maximum yield occurred with latitude for the Two-Pass Glyphosate and PRE + Glyphosate treatments, and strong positive increases occurred in maximum yield with latitude for One-Pass Glyphosate and PRE/POST treatments. For weed diversity, there were no latitudinal trends, but distinct treatment effects: weedy checks had highest weed densities, but not necessarily the highest e^H', and this was consistent between years; One-Pass Glyphosate always had high diversity; Two-Pass Glyphosate and Standard PRE + Glyphosate had the best weed control and lowest diversity; and Standard PRE/POST also had low diversities, but not necessarily low densities. The One-Pass Glyphosate treatment allowed for the expression of the greatest diversity, apparently by suppressing the dominant species, thereby allowing less common species too express themselves in the population. If weed diversity is valued by society, as in Europe, farmers can maintain better diversity with a One-Pass Glyphosate application than with traditional treatments and still maintain high yields, but only at higher latitudes. Below 45^{o} N latitude, yields in the One-Pass Glyphosate treatment decreased by about 2% per degree of latitude. During 2001 about 70% of the variation surrounding the number of weed escapes found at the study sites could be explained simply by the abundance of weeds found in weedy check plots. That is, weedy fields tended to have more escapes than clean fields. However, during 2002, only 13% of the variation could be explained by general weediness of experimental sites. Delayed emergence played an important role in governing the likelihood to escape control. Escaped species were those that had low levels of emergence when glyphosate was applied, especially at the first application. Fecundity of late-emerging plants may be a key to understanding proliferation of some species in cropping systems that use glyphosate frequently. The number of escapes in the Two-Pass Glyphosate treatment was an order of magnitude less than that in the One-Pass Glyphosate treatment. Seeds of plants that previously were exposed to field rates of glyphosate sometimes produced seedlings that tolerated dilute glyphosate applications better than plants not previously exposed to glyphosate. This phenomenon was most obvious in common lambsquarters (*Chenopodium album*), which was the most frequently observed species that escaped control by glyphosate in our studies.

WEED GARDENING AT THE PURDUE UNIVERSITY DIAGNOSTIC TRAINING AND RESEARCH CENTER. Loree B. Johnston and Gregory L. Willoughby, Graduate Research Assistant, Department of Botany and Plant Pathology, Purdue University West Lafayette, IN 47907-1155; and Former Director of Center now at Helena Chemical Corporation, Carmel IN 43032.

Every year, over one thousand agricultural professionals attend training sessions at the Purdue University Crop Diagnostic Training and Research Center at either the Agronomy Research Center (ARC) in West Lafayette, IN or the Northeast Purdue Agricultural Center (NEPAC) in Columbia City, IN. Training sessions are used to sharpen crop problem trouble shooting skills using hands-on teaching techniques. Participants see in-field demonstrations covering micronutrient applications, fertilizer placement, herbicide demonstrations, insect resistant crops and crop diseases in corn, wheat, soybeans and alfalfa.

A weed identification garden was created to give participants a chance to see weeds which the may not usually encounter and practice identification skills. There are 90 specimens at ARC and 35 at NEPAC. Each ring is a 3-foot wide by 4-foot deep plastic pipe buried in the ground. The ring has a single weed species planted in it. The rings are hand-weeded and sprayed with selective herbicides after the weeds have been planted. Weeds were grown in the greenhouse, sewn into the rings or transplanted from fields. The weeds are grouped by family, with similar weeds next to each other. During training sessions plots were utilized in various ways including looking at the weed garden at their own leisure, walked thru by a weed expert or given a mini-quiz over weed identification. Participants have given much positive feedback about the look of the garden and its layout. Future plans for the garden include grouping weeds by cropping system affected, grouping by timing of emergence or control windows, all while trying to time weed stages to match the time of the training sessions.

COMPARISON OF WEEDSOFT AND AGRI-CHEMICAL DEALER RECOMMENDATIONS IN ILLINOIS. Aaron N. Dufelmeier and George F. Czapar, University of Illinois Extension, Jacksonville, Illinois 62650.

The Illinois version of WeedSOFT 2002 was compared with four agri-chemical dealer recommendations for post emergence weed control in corn. Field experiments were conducted in two locations during 2002. Both locations were no-till corn planted the 4th week of May. Location one was corn following soybean and location two was corn following corn. Pre-plant herbicides were used at each location. In each field, weed species, density, and size were recorded in five locations. Weed infestation in field one consisted of a very high density of waterhemp, scattered or very low density of yellow nutsedge, cocklebur, common ragweed, pokeweed, and black nightshade. Weed infestation in field two consisted of an intermediate to high infestation of velvetleaf followed by low populations of sunflower, horsenettle, hemp dogbane, and giant foxtail. There was also a minimal infestation of giant ragweed and morningglory. The WeedSOFT recommendation applied to each field experiment was sorted by percent maximum yield. This recommendation was compared to four agri-chemical dealer recommendations as well as to the producers herbicide program. Herbicides recommended by WeedSOFT were applied and compared to the producer standard. The design was randomized-complete block, with three replications. Herbicide effectiveness ratings were taken at two weeks and eight weeks after applications. In both locations harvest data was also collected in order to compare yield differences between all chemical replications.

USING A SELF-ASSESSMENT TOOL TO PROMOTE AND EDUCATE INTEGRATED PEST MANAGEMENT TO FARMERS. Richard T. Proost, Bryan M. Jensen, Daniel J. Heider and Chris M. Boerboom, Senior Outreach Specialist, Program Manager, Program Manager, and Professor, Nutrient and Pest Management Program, Integrated Pest Management Program, Integrated Pest Management Program and the Department of Agronomy, University of Wisconsin, Madison, WI 53706

The National Integrated Pest Management (IPM) Initiative was announced in 1994 with the intent to "achieve the national goal of IPM implementation on 75% of crop acres by the year 2000." For the most part, this goal has been met on high value crops such as apples, grapes, and potatoes. However this goal has not been met on commodity crops such as corn and soybean. A variety of reasons for the lack of IPM adoption exist, including physical constraints of the farm, government programs, knowledge base, time and labor requirements, and the perception f increased risk. Furthermore, many farmers are confused or unsure of which practices even constitute IPM.

Creating awareness and interest in IPM practices and relating them directly to the farm can help to promote and increase adoption. The "Pest Management Assessment for Field Corn", a farmer self-assessment, was developed to help farmers take credit for IPM practices that they currently use and to provide an awareness of other IPM practices they may wish to consider. The assessment consists of questions in four categories: general, weed, insect, and disease management. The assessment is administered either as part of crop production meeting or via an Internet website (http://ipcm.wisc.edu/surveys/corn/). Farmers are assured complete confidentially, as the assessment is not collected, or in the case of the Internet, not linked to them. The total point values for each category are collected to calculate averages and ranges, which are then reported back at the end of the meeting or posted on the website.

To date, 100 farmers and 28 Farm Short Course students have taken the assessment at meetings or in the classroom. The Internet site was recently launched (November, 2002) and has yet to be fully utilized. Assessment results indicate that corn farmers in Wisconsin have the potential for significant improvement before reaching a high level of IPM adoption. On average, farmers received 67, 51, 47 and 55% of the possible points in the general (57 points), weed (115 points), insect (83 points) and disease (40 points) categories, respectively. Furthermore, the range of scores indicated a wide degree of IPM adoption. Point ranges were 15 to 57, 26 to 99, 7 to 80 and 2 to 38 for general, weed, insect and disease management sections, respectively. Further refinements to the assessment include the addition of soybean and alfalfa to both the printed copy and the Internet version. The ultimate goal is to develop a farm wide assessment that will relate IPM practices directly to the farmer in a confidential manner.

FOUR YEAR SUMMARY OF WEED SPECIES OBSERVED BY SCOUTING NINE KENTUCKY CORN AND SOYBEAN FIELDS. Michael W. Marshall, J.D. Green, and J.R. Martin, Research Specialist, Extension Professor, Extension Professor, Department of Agronomy, University of Kentucky, Lexington, KY 40546.

A survey was initiated in 1998 and 1999 to determine the baseline weed species composition in Kentucky corn and soybean fields before the introduction of genetically tolerant crop varieties. Within the span of 4 years, it has been estimated that 80% of soybeans planted have the Roundup Ready technology and, in Kentucky, approximately 30% of corn acres have been planted with Clearfield corn hybrids. However, a potential exists for a shift in the dominant weed species in response to these new herbicide programs. The objectives of this study were to develop a baseline of the most frequently occurring weed species that infest Kentucky corn and soybean fields, to develop a long-term assessment of the impact of herbicide tolerant crop technology on the occurrence of weed species and, with these assessments, determine if these practices resulted in a shift in the dominate weed species present. For the statewide baseline assessment, ten counties were chosen in 1998 and 1999, which consisted of 64 soybean fields and 39 corn fields, representing approximately 4700 acres. For the long-term annual assessment, the focus was narrowed to 8 fields in Taylor County and 1 field in Hardin County. Fields were surveyed approximately 3 to 5 weeks after planting, but before any postemergence herbicide treatment. The scouting procedure consisted of a S-shaped pattern where the total number of survey sites within a field were determined by a set number of paces which divides a field into 5 acre blocks or segments. For example, 4 sample sites would be used to represent a 20 acre field. In addition, at each of the survey sites, a handheld GPS unit was used to record the exact location using GIS-GPS satellite system. At each survey site, the weed species present and relative density of each weed species was determined. In addition, the following production practices were noted: tillage, crop variety and growth stage, planting date, and herbicide program. Percent frequency occurrence of individual species was calculated as the number of sites where the weed species was detected divided by the total number of sites in a given field. Weed species were ranked according the percent frequency of occurrence. In statewide soybean fields, the following species were detected: prickly sida > johnsongrass > honeyvine milkweed > ivyleaf morningglory > smooth pigweed. Similarly, in statewide corn fields, the following species were detected: smooth pigweed > johnsongrass > yellow nutsedge > horsenettle > ivyleaf morningglory. In Taylor County soybean fields, prickly sida, common lambsquarters, and giant foxtails were among the most prevalent species detected in 1999; however, the 2002 survey indicated that ivyleaf morningglory, horseweed, and johnsongrass were observed most frequently. Similarly, the Taylor County corn fields, in 1999, showed that horsenettle, smilax spp., and johnsongrass were the most prevalent, but, during the 4 year scouting program, dandelion, smooth pigweed, broadleaf signalgrass, and pitted morningglory became the most frequent or prevalent. For a more detailed analysis, two fields in Taylor County and one field in Hardin County were selected. The top five weed species found during the 1999 baseline survey in the two Taylor County fields were broadleaf signalgrass, horseweed, ivyleaf morningglory, pitted morningglory, and common lambsquarters. Broadleaf signalgrass and pitted morningglory remained among the most frequently detected species through 2002. However, in Hardin County, perennial dicots were among the most prevalent species found in 1999. Similarly, honeyvine milkweed and hemp dogbane remained the most frequently detected species through 2002. In conclusion, annual morningglories remained at or near the top of the weed ranking due to ability to escape control measures. In soybeans, certain weed species, such as horseweed, increased due to changing herbicide programs, such as lack of soil residual treatments. Johnsongrass remained a commonly observed species, but mainly as seedling plants. Due to no-tillage production practices, perennial dicots, such as honeyvine milkweed, hemp dogbane, and common pokeweed, increased in severity or frequency. Also, marginal species, such as brambles spp., smilax spp., and tree saplings, were detected.

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GLYPHOSATE TOLERANT ASIATIC DAYFLOWER (COMMELINA COMMUNIS) CONTROL IN NO-TILL SOYBEANS. Jim A. Fawcett, Extension Crop Specialist, Iowa State University, Ames, IA 50011.

Asiatic dayflower is an annual monocot weed in the Spiderwort family that has recently become a problem for some crop producers in eastern Iowa. Its relative tolerance to glyphosate and lengthy period of emergence has made it a challenge to manage in soybeans.

A trial was conducted in 2002 in a field near Vinton, IA to investigate alternatives for controlling Asiatic dayflower in soybeans. Roundup Ready® soybeans were planted in 75-cm rows without tillage on May 7, 2002. Herbicide treatments were applied with a CO_2 backpack sprayer to 3 m by 7.5 m plots in a randomized complete block design with three replications. All applications were made using a carrier volume of 234 L/ha. All glyphosate applications included ammonium sulfate at 3% by weight. Visual evaluations of Asiatic dayflower control were made throughout the season.

Applications of clomazone and of flumioxazin made 3 days after planting did not provide acceptable control of Asiatic dayflower. Postemergence applications of bentazon, aciflourfen, lactofen, flumiclorac, imazamox, and fomesafen to 5- to 30-cm Asiatic dayflower provided little to no control of the weed. A planting time application of glyphosate at 0.84 kg ae/ha followed by an application of glyphosate to 10- to 30-cm Asiatic dayflower at rates up to 1.68 kg ae/ha made 63 days after planting did not provide acceptable control of the weed. However, more timely glyphosate applications did provide better control. Three glyphosate applications of 0.84 kg ae/ha at 3, 44, and 63 days after planting to 2- to 20-cm Asiatic dayflower provided greater than 80% control. Cloransulam-methyl at 18 g/ha applied to 2- to 20-cm dayflower also provided greater than 80% control. The greatest control with soil-applied herbicides occurred with cloransulam-methyl and with sulfentrazone.

RESPONSE OF GLYPHOSATE TOLERANT AND SUSCEPTIBLE BIOTYPES OF HORSEWEED (*CONYZA CANADENSIS*) TO FOLIAR APPLIED HERBICIDES. James R. Martin and William W. Witt, Extension Professor and Professor, Department of Agronomy, University of Kentucky, Princeton, KY 42445

Glyphosate is usually more effective than paraquat for providing burndown control of horseweed (also known as marestail). However, it does not provide effective control consistently, particularly at the low glyphosate rates currently used by many growers. There were isolated cases where multiple of applications of glyphosate failed to provide complete control of horseweed in Kentucky during 2001. Due to these unique circumstances, studies were conducted in 2002 at a farm site in Trigg County and at two sites on the UKREC near Princeton to evaluate strategies for horseweed control and to determine if glyphosate tolerant biotypes existed in Kentucky. Although crops were not planted in these studies, the timing of treatments were done to simulate burndown or in-season applications for Roundup Ready soybeans.

The Trigg County site was chosen because it had problems with escapes following multiple applications of glyphosate in 2001. Results of the Trigg County study in 2002 indicated this population had a high level of tolerance to glyphosate. Applying glyphosate at 0.75 lb ae/A to four-inch tall plants on April 25, resulted in only 60% control by June 6. These plants continued to survive when treated again on June 6 with an in-season application of glyphosate at 0.75 lb ae/A. The overall control rating, which accounted for burndown control of treated plants and residual control of newly emerging plants, was only 10% for this treatment on July 8. Using a similar approach, but increasing the rate of the in-season application of glyphosate to 1.125 lb ae/A, resulted in only 66% overall horseweed control on July 8. The addition of 2,4-D ester at 0.5 lb ae/A or cloransulam at 0.016 lb ai/A with glyphosate, tended to improve burndown control of treated plants, but control of late emerging plants was variable. However, the overall control on July 8 was at least 91% when both 2,4-D and cloransulam were mixed with glyphosate in the April 25 early preplant burndown treatment, or when the combination of 2,4-D plus glyphosate was applied as an April burndown spray followed by an in-season application of cloransulam plus glyphosate. The use of paraquat at 0.75 lb ai/A as a tank mix partner with cloransulam or with cloransulam plus 2,4-D as early preplant treatments followed an in-season application of glyphosate, provided 100% overall control on July 8. The in-season application of cloransulam plus glyphosate tended to improve control of plants previously treated with an early preplant application of glyphosate alone, but overall control was still only 63% by July 8. Subsequent greenhouse studies of plants collected from the Trigg County site confirmed this population was highly tolerant to glyphosate.

The two experiments at UKREC dealt with populations of horseweed that were more susceptible to glyphosate compared with the population in Trigg County. Treatments in the first UKREC study were applied on May 16 when horseweed was approximately 10 inches in height. The level of burndown control of horseweed in this study was 98% with glyphosate at 0.75 lb ae/A, 53% with cloransulam at 0.016 lb ai/A, 67% with 2,4-D at 0.5 lb ae/A, and 100% with glyphosate at 0.75 lb ae/A plus 2,4-D at 0.5 lb ae/A. In the second UKREC experiment, horseweed plants were mowed to an average height of five inches and treated on May 31. Glyphosate applied at 0.56, 0.75, 1.125, and 1.5 lb ae/A resulted in 77, 86, 93, and 100% burndown control of horseweed, respectively. The use of tank mix partners such as 2,4-D at 0.5 lb ae/A, cloransulam at 0.016 lb ai/A, or the premix of chlorimuron plus sulfentrazone at 0.14 lb ai/A tended to improve burndown control with glyphosate at the low rate of 0.56 lb ae/A. However carfentrazone at 0.008 lb ai/A or flumioxazin at 0.064 lb ai/A did not improve horseweed control when combined with glyphosate.

Results of these experiments indicate that glyphosate - tolerant biotypes of horseweed are present in Kentucky, and that herbicides with other sites of action are needed to provide effective burndown and residual control of this weed. The fact that glyphosate-tolerant and ALS-resistant biotypes have been

observed in neighboring states, makes it critical to develop strategies with alternative modes of action and to monitor fields for regrowth.

POSTEMERGENCE HERBICIDES FOR CONTROL OF COMMON DANDELION IN NO-TILLAGE CORN. 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.

The occurrence of common dandelion (*Taraxacum officinale*) in Michigan no-tillage corn production has increased over the past several years. Producers have been reporting inconsistent common dandelion control, especially when glyphosate is the primary herbicide applied. To address this issue, several postemergence corn herbicides, premixes and tank mixtures were evaluated for common dandelion control. Research was conducted at the Michigan State University Clarksville Experiment Station on an established population of common dandelion. Glufosinate-resistant corn was planted in 76 cm row spacing. Herbicide treatments were applied when corn reached the V5 growth stage. Common dandelion control was evaluated weekly and plots harvested for yield.

Commercial postemergence corn herbicides evaluated in the study include: 2,4-D amine, 2,4-D ester, dicamba, clopyralid, halosulfuron, primisulfuron, nicosulfuron, carfentrazone, flumiclorac, bromoxynil, atrazine, bentazon, mesotrione, and glufosinate. Premixes evaluated were: atrazine + 2,4-D ester, atrazine + dicamba, primisulfuron + dicamba, diflufenzopyr + dicamba, flumetsulam + clopyralid, and rimsulfuron + thifensulfuron. Tank mixes included in the study were mesotrione + atrazine and glufosinate + atrazine. All treatments were applied at labeled rates and with appropriate adjuvants.

The most effective treatments 21 DAT were the tank mixtures of mesotrione + atrazine and glufosinate + atrazine with 84 and 75 percent control, respectively. All other treatments were significantly less effective. When applied alone, mesotrione and glufosinate controlled common dandelion 72 and 55 percent, respectively. Atrazine applied alone controlled common dandelion 13 percent. Flumiclorac was the only postemergence herbicide treatment that did not result in a corn yield significantly greater than the 2900 kg ha^{-1} yield of the untreated. However, carfentrazone and flumiclorac had similar yields of 5300 and 3800 kg ha^{-1}, respectively. The treatments which resulted in the greatest yield were; mesotrione, glufosinate, mesotrione + atrazine, glufosinate + atrazine, 2,4-D ester + atrazine, and diflufenzopyr + dicamba with corn yields of 9300, 10500, 10600, 10300, 9200, and 9100 kg ha^{-1}, respectively. Atrazine applied alone resulted in a yield of 6300 kg ha^{-1}.

RESPONSE OF CLEARFIELD CORN HYBRIDS TO POSTEMERGENCE IMAZETHAPYR + IMAZAPYR APPLICATIONS. James R. Martin, J. D. Green, James Herbek, William W. Witt, and Michael Marshall, Extension Professor, Extension Professor, Extension Professor, Professor, and Research Specialist, Department of Agronomy, University of Kentucky, Lexington, KY 40564.

Since the introduction of corn hybrids tolerant to imidazolinone herbicides (designated as Clearfield™ hybrids) in 1997, approximately 30% of the corn acres in Kentucky are now planted using the Clearfield corn technology. The primary herbicide product used on imidazolinone tolerant hybrids is a premix of imazethapyr + imazpyr (Lightning). The Clearfield corn technology has benefited corn producers with the potential to control or suppress growth of troublesome weeds such as common pokeweed, honeyvine milkweed, johnsongrass , and broadleaf signalgrass in Kentucky's no-till production system. Although Clearfield corn technology has offered good yield potential, there have been occasional problems observed with corn ear development from having poor kernel set and/or pollination failure resulting in significant corn yield losses. Field studies were conducted in 2001 and 2002 to evaluate timing of herbicide application on corn yield and ear development and to screen Clearfield hybrids for injury potential due to imazethypyr + imazapyr (Lightning) applications at 64 g/ha. Corn ear development and weight per ear for two of four hybrids evaluated in one study in 2001 were significantly impacted only when Lightning was applied at the 2x herbicide rate and V9 growth stage compared to the V3 and V6 growth stages. Whereas, at another location no corn ear development problems were observed with application timing or herbicide rate. In 2002 the effect of application timing with Lightning at 3, 4, 5, and 6 weeks after corn emergence (V5 through V12 growth stage) were evaluated on three Clearfield corn hybrids. No significant differences in corn yield or percent corn ear damage were observed at any of the application timings. In addition, 44 Clearfield corn hybrids were screened for the potential impact of a late-season Lightning application on corn yield. Corn yields overall were low due to extremely dry environmental conditions with only one hybrid yielding significantly lower when applied with Lightning herbicide compared to the same hybrid left untreated. Results from these studies did not explain the poor kernel set and ear development that is sometimes observed with the Clearfield corn technology.

FALL HERBICIDES FOR ITALIAN RYEGRASS CONTROL PRIOR TO NO-TILL CORN. Ron A. Hines, Senior Research Specialist, Department of Crop Sciences, University of Illinois, Dixon Springs Agricultural Center, Simpson, IL 62985.

The use of some winter annual cover crops for soil erosion control prior to no-till crops can lead to significant weed control problems if seed development is not prevented. One such cover crop is Italian ryegrass. Seed germination and plant development can occur in the fall or early spring. Prevention of plant establishment in the fall can help minimize early plant maturity and seed development in the spring.

The objective of this study was to evaluate fall herbicide applications for control and establishment prevention of Italian ryegrass prior to no-till corn. The herbicide treatments included single and combination treatment of simazine, paraquat, glyphosate, 2,4-D, rimsulfuron plus thifensulfuron and tribenuron.

Italian ryegrass seed was broadcast over the entire trial area at 66 kg/ha on October 23, 2001. All fall herbicide treatments were applied on November 15, 2001 to one to three inch tall ryegrass.

Control results 30 days after application indicated that glyphosate or paraquat applied alone, combinations of simazine plus paraquat and combinations of glyphosate plus 2,4-D were all providing greater than 85 percent control. Simazine applied alone was providing less than 60 percent control.

Control results on April 16, 2002 indicated that only the treatment combination of simazine plus paraquat was providing at least 70 percent control of Italian ryegrass. No other treatment was providing more than 31 percent control.

This research indicates that the best fall control of volunteer Italian ryegrass will be obtained with the use of a combination of burndown and residual control herbicides.

FALL TREATMENTS FOR WINTER ANNUAL WEED CONTROL IN ROW-CROP STUBBLE. David L. Regehr and Dallas E. Peterson, Professors, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Studies begun in the early 1990's, to develop and evaluate Best Management Practices to minimize atrazine loss in surface water runoff, included fall and early spring applications of atrazine to avoid high runoff periods. It became apparent that soybean stubble fields treated with atrazine in fall or early spring, were not only weed-free at corn planting time the following spring, but had warmer and dryer soils than fields in which winter annual weeds were allowed to grow until preplant burndown herbicides were applied. In 1998, a section 24(c) Special Local Need Label was approved in KS, for atrazine applications in fall to row-crop stubble to be planted to corn or sorghum the next spring. Besides atrazine, other herbicides that have been evaluated for fall application ahead of corn or soybean include 2,4-D, dicamba, flumetsulam, metribuzin, nicosulfuron plus rimsulfuron, glyphosate, paraquat, isoxaflutole, chlorimuron, sulfentrazone, carfentrazone, and flumioxazin. In general, much lower rates are needed in fall applications than in spring. Field pansy (*Viola rafinesquii*) has emerged as a “new” winter annual weed problem for no-tillers in northeast KS. It tolerates many burndown herbicides applied in spring, and fall applications are being evaluated for its control.

A NEW HERBICIDE FOR AQUATIC USE: BAS 693H. Kathie E. Kalmowitz, Jeffrey H. Birk, Jennifer L. Vollmer, and Dan D. Beran, Market Development Specialist, Registration Specialist, Public Lands Specialist, and Market Development Specialist, BASF Corporation, Research Triangle Park, NC 27709.

BAS 693H herbicide is currently under review by Environmental Protection Agency (EPA) for an aquatic use label. The active ingredient, imazapyr, has been registered and used as an effective broad-spectrum herbicide in forestry and vegetation management sites for over 15 years. BAS 693H has been evaluated under an Experimental Use Permit (EUP) since 1995 for aquatic and terrestrial/ wetland uses. Currently 25 states are participating in the EPA approved EUP including: Arizona and Nevada and all states east to Virginia for the south/southwest; the MidAtlantic states of New Jersey and Pennsylvania and the North Central states of Ohio, Indiana, Michigan, Illinois, Wisconsin and Minnesota. Washington State, Nebraska and Montana are also approved in the BASF Aquatic EUP Program.

BAS 693H is in the imidazolinone family of chemistry and has low toxicity to mammals, birds, fish and reptiles. Research and EUP data supports BAS 693H for use on floating, emersed and riparian species for aquatic and wetland sites. No biological activity has been reported for control of algae species when BAS 693H was evaluated in laboratory and small tank studies by university researchers. Research results indicate specific submersed species would require elevated rates (higher than proposed use rates evaluated) and prolonged exposure times, for BAS 693H to provide significant control of the plant species. The half-life of BAS 693H is approximately 7-14 days in an aqueous environment; breakdown occurs through aqueous photolysis and microbial action to end products carbon, hydrogen, oxygen and nitrogen. Application methods to deliver the herbicide can provide selective control of targeted weed species and flexibility for time-of-application at the site.

Data demonstrate that BAS 693H when registered can provide season-long control of key invasive emergent and shoreline species. Examples of excellent control reported in research and EUP trials are purple loosestrife (*Lythrum salicaria*), cattail species (*Typha* spp.), alligator weed (*Alternanthera philoxeroides*), sedge species (*Carex* and *Cyperus* spp.), common reed (*Phragmites* spp.), water hyacinth (*Eichhornia crassipes*) and waterlettuce (*Pistia stratiodes*) when evaluated at rate ranges of 0.5-1.5 lb a.e. /surface acre. Elsewhere in the country, effective use of BAS 693H has been observed with control of invasive terrestrial species saltcedar (*Tamarix* sop.), Malaleuca (*Melaleuca quinquenervia*), and Chinese tallow tree (*Sapium sebiferum).*

BAS 693H, when registered, can provide a new aquatic-weed-control option for restoration of aquatic, wetland and riparian areas.

ANNUAL FLOWER RESPONSE TO SIMULATED DRIFT FROM SYNTHETIC AUXIN HERBICIDES. Harlene M. Hatterman-Valenti, Assistant Professor, Plant Sciences Department, North Dakota State University.

Greenhouse studies were conducted to evaluate simulated drift injury to annual bedding plants. Dahlia, gazania, geranium, marigold, petunia, and salvia in the early stages of flowering were sprayed with either 2,4-D (dimethylamine salt) or dicamba (diglycolamine salt) at rates $1/5$th, $1/10$th, or $1/20$th the lowest labeled rate of for turfgrass. Interactions between species by time, species by treatments, and treatments by time were significant for visual injury. Species sensitivity from most sensitive to least sensitive was marigold > dahlia >> geranium ⊄ petunia > gazania ⊄ salvia. Dahlia was more sensitive to dicamba than 2,4-D while the opposite was true for marigold. Petunia flower initiation was reduced as dicamba or 2,4-D rate was increased. The duration of the trial may have limited flowering differences among treatments with the remaining species. Dahlia loss of apical dominance as an injury response was greater with dicamba than 2,4-D. Typical injury symptoms for dahlia included stem, leaf, and petiole epinasty along with multiple shoot growth. Gazania injury included slight leaf rolling and leaf stretching. Geranium injury included leaf curling and fewer flowers per cluster. Marigold injury included leaf node swelling and stem wall rupture with massive cellular proliferation. Petunia injury included stem and pedicel epinasty, curling of the outer portion of the corolla, and lower flower production. Salvia injury included stunting, slight flower stem curvature, and partial dieback of the terminal raceme.

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RESPONSE OF FRASER FIR AND PERSISTENT WEEDS TO PREEMERGENCE AND POSTEMERGENCE HERBICIDES. Robert J. Richardson, Bernard H. Zandstra, and Joeseph G. Masabni, Research Associate, Professor, and Former Research Associate, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Field studies were conducted in 2001 and 2002 to evaluate Fraser fir and weed response to selected herbicides in two commercial Christmas tree plantations near Gobles and Hart, Michigan. Treatments in the fall 2001 studies included 2 lb ai/A simazine, 1 lb ai/A oxyfluorfen, 1 lb ai/A isoxaben, 1 lb ai/A azafenidin, 0.4 lb ai/A flumioxazin, 3 lb ai/A pendimethalin, 4 lb ai/A oryzalin, 0.2 lb ai/A halosulfuron, and 0.5 lb ai/A sulfentrazone. Spring 2002 studies included simazine, oxyfluorfen, isoxaben, flumioxazin, pendimethalin, 2 lb ai/A pronamide, and sulfentrazone. Midseason 2002 studies included 1 lb ai/A bentazon, 0.125 lb/A oxyfluorfen, 0.047 lb/A halosulfuron, 0.19 lb ai/A clopyralid, 0.12 and 0.25 lb/A flumioxazin, and 0.5 lb ai/A bromoxynil. In fall 2001 studies, field pansy was controlled greater than 79% at both locations by oxyfluorfen, azafenidin, flumioxazin, and sulfentrazone and common ragweed was controlled greater than 80% by isoxaben, azafenidin, and halosulfuron. At Hart, hoary alyssum was controlled at least 88% by isoxaben, azafenidin, flumioxazin, halosulfuron, and sulfentrazone; annual grasses were controlled greater than 80% by azafenidin, flumioxazin, pendimethalin, and oryzalin. Goosegrass was controlled 58% by azafenidin at Gobles while control with other herbicides did not exceed 20%. Horseweed control was generally good at Gobles, except with pendimethalin and oryzalin, which did not control the weed. In the spring 2002 studies, hoary alyssum was controlled 77 to 88% at the Hart location by simazine, isoxaben, and sulfentrazone, while common ragweed was controlled only by flumioxazin. Annual grasses were controlled at least 73% by all applications. Field pansy was only controlled by oxyfluorfen at both locations. At Gobles, horseweed was only controlled by sulfentrazone and no treatments controlled common ragweed greater than 70%. No significant Fraser fir injury was observed from any fall or spring treatments. In the midseason 2002 studies, hoary alyssum, common milkweed, and field pansy were not controlled greater than 70% by any treatment at Hart. White campion was controlled 80% by halosulfuron and common ragweed was controlled 80% or greater with halosulfuron, clopyralid, and bromoxynil. At Gobles, horseweed was controlled 97 to 100% with bentazon, halosulfuron, and bromoxynil. Fraser fir injury ranged 29 to 57% at both locations from bentazon, halosulfuron, flumioxazin, and bromoxynil.

CONTROL OF HORSEWEED WITH GLYPHOSATE. Glen P. Murphy, Tim E. Dutt, Robert F. Montgomery, Teresa S. Willard, and Greg. A. Elmore, Monsanto Company, St. Louis, MO.

Horseweed (*Conyza canadensis*), commonly referred to as marestail, can be a difficult weed to control with glyphosate. The Monsanto field trial database was searched to determine the historical effectiveness of glyphosate in controlling horseweed. This search of spring burndown applications included data from trials conducted at multiple locations across the United States from 1973 to 2000. Data averages from this search showed better than 90% control of horseweed up to 12 inches tall at application with 0.75 lb. acid equivalent (ae) glyphosate per acre. Control averages dropped to less than 60% as the height of horseweed increased up to 36 inches at application. The addition of 2,4-D at 0.5 lb active ingredient (ai) per acre to glyphosate improved horseweed control. In general, there was better and more consistent control with glyphosate when horseweed was smaller and when 2,4-D was added.

Laboratory and field tests have recently confirmed the presence of glyphosate-resistant horseweed biotypes in Delaware and Tennessee. Field trials were also conducted in New Jersey, Maryland, Delaware, and Kentucky during 2001 and 2002 to determine the most effective programs for control of horseweed with glyphosate in no-till glyphosate-resistant soybeans (*Glycine max)*. In these tests, a spring burndown application of glyphosate @ 0.75 lb ae/A + 2,4-D @ 0.5 lb. ai/A + cloransulam @ 0.016 lb. ai/A followed by an in-crop application of glyphosate @ 0.75 lb. ae/A resulted in an average 96% control with 90% or better control obtained at all locations. Glyphosate + 2,4-D (burndown) followed by glyphosate + cloransulam (in-crop) resulted in an average 91% control with better than 90% control obtained at 4 of 6 locations. Glyphosate + 2,4-D (burndown) followed by glyphosate (in-crop) resulted in an average 76%. Glyphosate (burndown) followed by glyphosate + cloransulam (in-crop) resulted in an average 57% control with better than 90% control obtained at only 1 of 6 locations. Results indicate that control of horseweed with glyphosate can be variable depending on the biotype (susceptible or resistant), stage of growth, and environmental conditions. The addition of 2,4-D increased control of horseweed at burndown. Cloransulam also increased horseweed control especially when combined with 2,4-D at burndown or when applied with glyphosate @ 0.75 lb ae/A as an in-crop application following glyphosate plus 2,4-D. Testing showed it is best to control horseweed when it is small (<6 inches) with a spring burndown application before soybean planting.

Monsanto recommends glyphosate @ 0.75 lb ae/A plus 2,4-D applied preplant for control of horseweed prior to planting soybean and corn. Preplant applications should be made prior to horseweed reaching 6 inches in height. Cloransulam plus glyphosate @ 0.75 lb ae/A is recommended for in-crop applications in glyphosate resistant soybeans where preplant control efforts were not effective in controlling horseweed. Atrazine and atrazine containing premix products may be added to preplant applications in corn for enhanced control. In-crop applications for glyphosate resistant corn should include glyphosate plus 2,4-D or dicamba where preplant control efforts were not effective in controlling horseweed.

EFFECTS OF SOIL INSECTICIDES ON FIELD CORN TOLERANCE TO POSTEMERGENCE APPLICATIONS OF MESOTRIONE. Scott C. Ditmarsen*, Steven Nolting, Mark A. Peterson, Sarah Taylor-Lovell, and Larry G. Thompson. Dow AgroSciences, LLC, Indianapolis, IN 46268.

Field experiments were conducted at five Midwest locations in 2002 to evaluate the effects of various soil insecticide treatments applied at planting on the tolerance of field corn to subsequent postemergence applications of mesotrione plus atrazine. Insecticide treatments included: chlorpyrifos (Lorsban 15G) at 1X (11.25 g ai/100m of row) and 4X; terbufos (Counter 20CR) at 1X (11.25 g ai/100m of row) and 4X; and tefluthrin (Force 3.0G) at 1X (1.125g ai/100m of row). All insecticide treatments were applied in-furrow. Treatments with no insecticide were included for comparison. Herbicide treatments included postemergence applications of mesotrione + atrazine at 1X (105 + 280 g ai/ha), 2X, and 4X rates and mesotrione alone at the 4X (105 g ai/ha) rate, all applied at the V4 stage of corn growth. All herbicide treatments contained crop oil concentrate at 1.0% v/v and urea-ammonium nitrate solution (UAN 28%) at 2.5% v/v. Visual crop injury evaluations were taken at 0, 3, 7, 14, and 28 days after herbicide application.

The highest level of corn injury was noted at approximately 1 week after herbicide application. Symptoms were mainly an irregular loss of pigmentation in the treated foliage and some growth inhibition. Results of these studies showed that postemergence application of mesotrione + atrazine caused significantly less crop injury following application of chlorpyrifos or tefluthrin than terbufos. Injury from a 2X application rate of mesotrione + atrazine 1 week after application averaged 4, 7, 7, and 19% following treatments of no insecticide, 1X tefluthrin, 1X chlorpyrifos, and 1X terbufos, respectively.

IN ROW AND BETWEEN ROW ZONE HERBICIDE APPLICATION AT DIFFERENT RATES CONTROLS ANNUAL WEEDS AND REDUCES TOTAL RESIDUAL HERBICIDE USE IN CORN.

William W. Donald, Research Agronomist, U. S. Department of Agriculture, Agricultural Research Service, William G. Johnson, Assistant Professor, Agronomy Department, University of Missouri, Columbia, MO 65211, Kelly Nelson, Research Agronomist, Greenley Research Center, P.O. Box 126, Novelty, MO 63460 and David Archer, U. S. Department of Agriculture, Agricultural Research Service, North Central Soil Conservation Research Lab., 803 Iowa Ave., Morris, MN 56267.

New best management practices are needed to reduce offsite herbicide, nutrient, and sediment movement in runoff from farm fields and minimize herbicide contamination of surface and ground water without compromising soil conservation or economic goals. Zone herbicide application (ZHA) is a practical, generic approach for achieving some of these goals. It uses 1) crop management to enhance crop competitiveness with weeds, 2) soil residual herbicide banded over crop rows at reduced rates and 3) the same herbicide banded between rows at higher rates than over crop rows, so that total herbicide use per unit area is reduced. The goal of this research was to determine the impact of reduced rate zone herbicide application on weed control (chiefly giant foxtail, waterhemp species, common ragweed, common cocklebur, smartweed species and velvetleaf), grain yield, and economic return on herbicide investment in field corn. Preemergence zone herbicide applications of atrazine + metolachlor + clopyralid + flumesulam were made in bands at different rates between and over crop rows at two sites in Missouri. The 1X rate of atrazine + s-metolachlor + clopyralid + flumetsulam equaled 2.24 + 1.75 + 0.211 + 0.067 kg ai/ha, respectively. Treatment effectiveness was measured as reduced between-row and in-row total weed ground cover, increased crop grain yield, and increased economic return on investment. At both sites, zone herbicide application treatments (0.25 X in row rate + 0.75 to 1 X between row rate) outperformed all reduced rate broadcast herbicide treatments (0.25 X, 0.5 and 0.75X), based on these criteria. When compared to the 1X broadcast application, zone herbicide application reduced total herbicide applied per unit area 37 to 50%. In order to adopt ZHA, existing sprayers will require relatively minor, inexpensive modifications. Input cost savings for herbicides over time will dwarf initial costs for modifying sprayers and will drive adoption rather than government regulation or subsidies. ZHA is also scale independent and can be adopted on many farm sizes. ZHA is compatible with no-till farming methods, which can help prevent soil erosion and sediment contamination of surface water. Zone herbicide application may provide farmers with a new option for reducing herbicide rates and input costs while lessening the change of surface water contamination by herbicides.

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TIME OF WEED REMOVAL AND CROP PERFORMANCE IN A TWIN-ROW PRODUCTION SYSTEM. Kelly A. Nelson, Assistant Professor, Department of Agronomy, University of Missouri, Novelty, MO 63460.

Research was conducted to evaluate the impact of weed removal timing on twin-row corn and soybean performance compared with standard row spacings in 2002. Additional research evaluated weed-free twin-row corn and soybean performance compared to standard row spacings in 2001 and 2002. A twin-row crop is planted in 19 cm rows which are on 76 cm centers. Corn seed was planted in twin- and 76 cm wide-rows. Soybean seed was planted in 19 cm, 38 cm, and twin-rows. Twin-row corn intercepted a greater percentage of photosynthetically active radiation than 76 cm wide-row corn; however, light interception was greatest in 19 cm wide-row soybean when compared with 38 cm wide- or twin-rows. Corn grain yield for weed-free 76 cm wide-row and twin-row corn was similar to the 10 and 15 cm weed removal timings. Weed removal of 10 to 30 cm weeds in 19 cm, 38 cm, and twin-row soybean resulted in grain yields similar to the weed-free control for each row spacing, respectively. Soybean grain yield in 19 and 38 cm wide-row soybean was greater than twin-row soybean when weeds were removed at the 30 cm height. Eight site years of research in weed-free corn indicated that there was no grain yield benefit of twin-row corn compared to 76 cm wide-rows. Soybean grain yield in 19 cm wide-rows was 4.5 bu/a greater than 38 cm wide- or twin-row cultures.

A12854 APPLIED POSTEMERGENCE WITH ADJUVANTS. Richard K. Zollinger and Jerry L. Ries, Associate Professor and Research Specialist, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Studies were conducted in the field to determine kochia and yellow foxtail control from A12854 (premix of mesotrione, s-metolachlor, and atrazine) applied POST. A12854 at 0.1+1+0.38 lb/A with or without petroleum oil adjuvant and nitrogen fertilizer gave 95% control of 3 to 4 inch kochia. Nicosulfuron&rimsulfuron (nic&rim) at 0.38 or 0.56 oz/A applied with A12854 at 0.1+1+0.38 lb/A plus petroleum oil + nitrogen gave at least 92% control of 2 to 4 inch yellow foxtail. However, when applied to 3 to 6 inch yellow foxtail, only the higher nic&rim rate with A12854 gave 92% control. A12854 + petroleum oil + nitrogen gave greater yellow foxtail control at any rate used compared to mesotrione + atrazine + petroleum oil + nitrogen applied together at comparable rates. Nic&rim at 0.28 oz/A applied with A12854 at 0.13+1.3+0.5 lb/A plus petroleum oil + nitrogen completely controlled 3 to 6 inch yellow foxtail. Maintaining the nic&rim rate but reducing A12854 rate reduced yellow foxtail control to less than 75%. Nic&rim at 0.28 + A12854 at 0.07+0.67+0.25 lb/A applied with several nonionic surfactant, basic pH blend, petroleum oil adjuvants did not give adequate yellow foxtail control. Using MSO or MSO&basic pH blend (Renegade) adjuvants increased yellow foxtail control to at least 88%. Formsulfuron at 1.05, 0.88 or 0.7 oz/A + A12854 at 0.1+1+0.38 lb/A did not provide greater than 65% control.

RESPONSE OF TEN CORN INBRED LINES TO POSTEMERGENCE APPLICATIONS OF HALOSULFURON, DICAMBA AND NICOSULFOURON. M. Wayne Bugg, John Eberwine, Clint Pilcher and Chris Eichhorn, Technology Product Managers and Corn Breeder, Corn States Hybrid Services and Holden's Foundation Seeds, Des Moines and Williamsburg, IA.

Chemical weed control in inbred corn fields is an extra challenge compared to hybrid corn because of reduced canopy and increased herbicide sensitivity. This study was conducted at three locations in IL, IN and IA examining 2X normal use rates of halosulfuron, dicamba and nicosulfuron applied to 12 and 24 inch corn. Visual evaluations were made of vegetative injury and grain yields were measured. Results showed significant differences in response for both inbreds and herbicide treatments. Injury was greater with applications to 24 inch corn than to 12 inch corn. Growth reduction estimates taken 13-18 days after treatment showed the greatest separation between inbreds. Observations of chlorosis and malformation were variable across locations and differences between inbreds were not significant. Relative rankings of the 10 inbreds for vegetative tolerance correlated well with relative rankings based on yield. The relative safety of the herbicides based on yield response with the 24 inch applications was halosulfuron > dicamba > nicosulfuron. Inbreds with 'B73' in their background showed better tolerance than inbreds with 'LH82' in their background.

QUACKGRASS INTERACTIONS AND EFFECTS ON FORAGE SPECIES. Traci L. Bultemeier, David J. Barker, R. Mark Sulc, S. Kent Harrison, and Emilie E. Regnier, Graduate Research Associate, Assistant Professor and Associate Professors, Department of Horticulture and Crop Science, Ohio State University, Columbus, OH 43210.

Quackgrass is a troublesome weed in row crop production but has ideal forage characteristics for hay producers and animal grazers. Replacement series studies (2 runs) were conducted in the greenhouse to determine the competitive aspect of quackgrass under various defoliation frequencies, during the periods January-June and June-Novemeber 2002. Proportional mixtures (1:0, 1:2, 2:1, and 0:1) of quackgrass:white clover and quackgrass:orchardgrass and a 1:1:1 mixture of the three species were achieved by planting tillers, rhizome shoots or rooted stolons for orchardgrass, quackgrass and white clover respectively. Mixture treatments were subjected to either a two- or six-week cutting frequency. Results were similar for both runs and data have been combined into a single analysis of variance. Total aboveground biomass yield was significantly higher for the six-week cutting frequency than for the two-week cutting frequency. No difference in yield was found in the six-week cuttings of the quackgrass:orchardgrass mixtures, but a significant quadratic response ($p = < 0.05$) was found for the quackgrass:white clover mixtures, which showed a 23% greater yield from quackgrass:white clover mixtures than white clover alone. There was no yield response to any mixture within the two-week cuttings. Quackgrass is a productive forage species that yields best when grown with a complimentary species (i.e. white clover) rather than with a competitive species (i.e. orchardgrass).

GLYPHOSATE RESISTANT ALFALFA: THREE YEARS OF OBSERVATIONS. Jerry D. Doll, Sharie Fitzpatrick and Daniel J. Undersander, Extension Weed Scientist, Department of Agronomy, University of Wisconsin, Madison, WI; Director of Trait Integration, Forage Genetics Intl., West Salem, WI 54669; and Extension Forage Agronomist, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

An alfalfa variety with the CP4 gene for glyphosate resistance was evaluated in a field trial for herbicide tolerance and weed control. The experimental variety was planted at 18 lb/a on Apr. 19, 2000 in a conventionally prepared seedbed at the University of Wisconsin Agricultural Research Station near Arlington, WI. Plots were 3 by 16 ft and all herbicides were applied in 15 gal/a of water with their appropriate adjuvant. All glyphosate applications included AMS at 2.5 lb/a.. Two rates of glyphosate were applied one, two or three times to direct seeded and companion seeded glyphosate resistant alfalfa. This variety and a conventional variety ('LegenDairy') also received standard postemergence treatments with sethoxydim, clethodim or imazethapyr. Visual ratings of weed control or pressure and alfalfa vigor and forage harvests were taken regularly to measure herbicide performance and glyphosate tolerance. First cutting harvest data is presented as this one has the most biomass and usually the highest proportion of weeds.

Weed control in the seeding year was as expected for glyphosate and the standard herbicides. Quackgrass was present in the fall of 2000 in the companion seeded treatments that received glyphosate and in all treatments of the conventional variety. No quackgrass was observed in the direct seeded glyphosate resistant variety in 2000 nor at any time in this system when glyphosate was applied in the fall of each year. In spring 2002, quackgrass pressure averaged 13% in the glyphosate resistant variety that received only conventional treatments following seeding; in the conventional variety, quackgrass pressure averaged 17%. Common dandelion appeared in the summer of 2001and was present in all systems in the fall of that year. Glyphosate applied in October 2001 controlled all dandelions in the spring of 2002. Fall-applied glyphosate seems to offer excellent potential to maintain alfalfa free of common winter annual and perennial weeds and in-season applications would do the same with summer annual species.

The maximum quantity of glyphosate applied was 3.375 lb ae/a (1.125 lb in each of three applications). No injury was observed from this nor any other glyphosate treatment and alfalfa density after seeding and herbicide application was similar for all treatments. Yields for the first harvest were compared to the highest yielding treatment within each year and expressed as a percentage of that yield. The yield of direct seeded glyphosate resistant alfalfa treated three times with glyphosate averaged 89, 98 and 94% of the maximum yield in 2000, 2001 and 2002, respectively. The highest yielding treatment each year was always among these treatments. In 2001, first cutting yields of all treatments were similar, but in 2002 yields of the glyphosate resistant variety treated with glyphosate averaged 94% of the maximum versus 75% for all other systems with the same variety. The conventional variety that only received herbicides in the seeding year averaged 71% of the maximum first cutting yield in 2002. Alfalfa vigor was excellent for all treatments and both varieties in 2001 but in 2002, the glyphosate resistant variety was more vigorous that the conventional variety (average vigor rating over all treatments of 72% vs. 53%).

Glyphosate resistant alfalfa has excellent glyphosate tolerance and will allow complete and flexible weed management applications for nearly all weeds that appear after alfalfa establishment in any phase of the stand life. This technology may foster the adoption of no-till seeding methods to establish alfalfa and may enhance the use of temporary cover crops. Questions to be answered are whether this technology will increase the stand life alfalfa in the rotation, how often and when might glyphosate be used, the optimum rate to apply, and how the yield and feed value of varieties with the glyphosate resistance gene compare to commercial varieties.

WEED CONTROL AND GLYPHOSATE TOLERANT ALFALFA RESPONSE TO GLYPHOSATE RATE AND APPLICATION TIMING. Stephen D. Miller and Craig M. Alford, Professor and Assistant Research Scientist, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Weeds are a serious problem in both seeding and established alfalfa. Weeds compete with alfalfa for water, nutrients, and sunlight; thus reducing crop yields, shortening stand life, and lowering forage quality. Plots were established under furrow irrigation at the Research and Extension Center, Torrington, WY to evaluate weed control and glyphosate tolerant alfalfa response to three glyphosate rates (0.75, 1.12 and 1.5 lb/A) and five application timings (cotyledon, cotyledon + 3 weeks, 2nd trifoliolate, 2nd trifoliolate + 3 weeks and 4-leaf alfalfa) and compare these treatments to two commercial standards (imazethapyr+clethodim 0.063 + 0.078 lb/A and imazamox 0.047 lb/A). Plots were established in new seeding alfalfa (var. Forage Genetics RR) and were 9 by 30 ft. with three replications arranged in a randomized complete block design. Herbicide treatments were applied broadcast with a CO_2 pressurized knapsack sprayer delivering 10 gpa at 40 psi. Visual weed control and crop injury ratings were made two weeks following the last application and 1st and 2nd cut alfalfa and weed yields determined.

No alfalfa injury or stand reduction was evident with any treatment. Weed control with glyphosate was influenced by application timing but not rate. Glyphosate applications at the cotyledon or 2nd trifoliolate leaf stage required follow-up applications for complete weed control; whereas, glyphosate applications at the 4-leaf stage required no follow-up application. Weed control was better with glyphosate at all application timings than with the two commercial standards. Alfalfa yields were highest in plots where weeds were removed at the 2nd trifoliolate leaf stage or earlier and follow-up glyphosate applications did not increase alfalfa yields even though weed control was improved.

IMPACT OF CONSECUTIVE YEAR APPLICATIONS 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. Prior to pioneer settlement it was commonly found throughout the tallgrass prairie. 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 (currently sold under the tradename Plateau® herbicide) is a member of the imidazolinone herbicide family, and is a broad spectrum herbicide that provides contact, translocation, and residual activity on leafy spurge. The objective of this study was to evaluate the impact of consecutive year fall applications of imazapic, at rates used for the control of leafy spurge, on the population of western prairie fringed orchids. Under heavy leafy spurge infestations consecutive year applications of imazapic have proven to provide the most consistent and effective control. This consecutive year application pattern has become the standard in the Great Plains, thus the need to evaluate the impact on the western prairie fringed orchid. EPA through Nebraska Game and Parks Commission granted approval for this research. 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 and September 20, 2001. An additional 44 plants were left untreated for comparison. All plant areas were re-located on June 28, 2001 and July 2, 2002 for the presence or absence of the western prairie fringed orchid. Based on counts from both sites, the number of plants present in the imazapic treated plots were greater than or equal to the number present in the untreated plots for both single and consecutive year applications of imazapic. Dry weather from 2000 to 2001 and a significant drought in 2002, along with anthracnose leaf blight greatly affected orchid reemergence, growth, and flowering. These factors greatly influenced our ability to record floristic characteristic observations on the western prairie fringed orchid in the first and second year. The fact that nearly equal numbers of orchids reemerged in both the imazapic treated and untreated plots for both the single application and consecutive applications, even at low reemergence numbers, suggests that imazapic does not impact western prairie fringed orchid populations. Imazapic is registered for the control of leafy spurge in rangeland and pastures in the Great Plains of the United States. Thanks to the Venteicher and Zimmerman families for allowing this research to be conducted on their land.

HERBICIDE EFFECTS ON SERICEA LESPEDEZA SEED VIABILITY AND 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 introduced, perennial legume that is invading range and pasture land in the central Great Plains. Previous research on control has focused on the use of herbicides applied during rapid vegetative growth or during the bloom stage. The objectives of the current study were to determine if effective control can be obtained with herbicides applied during seed development and if certain herbicides would prevent viable seed production. The study with conducted at a site near Blaine, KS in 2001. Four herbicide treatments and a check were established in a factorial arrangement with four blocks on September 21, September 28, October 5, and October 12. Seed development ranged from early pod set on September 21 to the soft dough stage on October 12. The herbicides applied were triclopyr at 0.84 kg/ha, metsulfuron at 0.058 kg/ha, fluroxypyr at 0.32 kg/ha, and fluroxypyr + triclopyr at 0.14 + 0.42 kg/ha. Herbicides were applied in 187 L/ha spray volumes using a CO_2-powered backpack sprayer equipped with a four nozzle boom. Individual plots were about 2 by 8 m in size. Five sericea lespedeza plants per replication were harvested in early November. Seeds were threshed, counted, and a 14-day germination test conducted on scarified and unscarified seed in a growth chamber at 28^{o}C. Treatments were evaluated for percent control on July 17, 2002. Seed production increased from 41 to 202 seeds/plant as averaged across treatments over time. Percent germination of scarified seed was reduced by all herbicide treatments if applied before the milk to soft dough stage (October 5). Germination was < 3% for the triclopyr, metsulfuron, and fluroxypyr treatments applied on September 21 or September 28. Percent control declined across dates. Averaged across dates, all treatments provided > 70% control of sericea lespedeza. Metsulfuron at 0.058 kg/ha and triclopyr at 0.84 kg/ha were the most effective providing > 90% control.

BROADLEAF WEED CONTROL WITH BAS 662H AND TANK MIXTURES WITH BAS 662H IN RANGELAND, PASTURE, AND NONCROPLAND SITES. Dan D. Beran, Joseph G. Vollmer, C. Todd Horton, and Leo D. Charvat. Market Development Specialist, Market Development Specialist, Market Development Specialist, and Area Biology Manager. BASF Corporation, Research Triangle Park, NC 27709.

BAS 662H is a postemergence broadleaf herbicide being evaluated by BASF Corporation for use in range and pasture. BAS 662H currently has an EPA registration for use in non-crop areas for the control of annual and perennial broadleaf species. BAS 662H is formulated as a 70% WG, containing 55% sodium salt of dicamba (50% ae) and 21.4% sodium salt of diflufenzopyr (20% ae). Several studies were initiated in 2001 and 2002 to further evaluate the weed control spectrum and potential tank mixtures with BAS 662H. In two experiments conducted in South Dakota, BAS 662H applied at 295 and 392 g ae/ha averaged greater than 90% top growth control of Canada thistle one year after application at the spring rosette stage. Similarly, BAS 662H applied alone at 392 g ae/ha or in combination with clopyralid at 210 g/ha provided greater than 90% control of Canada thistle one year after treatment in Nebraska. BAS 662H also provided 100% control of musk thistle when applied at either 98 or 196 g ae/ha in two separate experiments conducted in Nebraska. In a noncropland site in North Carolina, BAS 662H was applied alone at 98, 196, and 295 g ae/ha and in combination with triclopyr amine at 105, 210, and 420 g/ha. Combinations of BAS 662H with triclopyr provided improved control of wild blackberry, buckhorn plantain, wild carrot, and sericea lespedeza when compared to similar or greater rates of triclopyr alone. In studies conducted in Nebraska, North Dakota and Utah, BAS 662H applied in the spring at 196 g ae/ha in combination with picloram at 140 and 280 g/ha provided improved control of leafy spurge when compared to similar rates of picloram alone.

NEW RANGELAND AND PASTURE HERBICIDE PRODUCT CONCEPTS. Robert A. Masters and Jeffery A. Nelson, Dow AgroSciences, LLC, Indianapolis, IN 46268

Woody and herbaceous weeds often reduce rangeland and pasture productivity and quality. Herbicides are effective components of integrated strategies to manipulate rangeland and pasture plant community succession to meet land management objectives. The Environmental Protection Agency is currently reviewing registration of the herbicide, fluroxypyr, for use in combination with triclopyr or picloram to manage rangeland and pasture weeds. Research has been conducted in the United States since 2000 to determine the efficacy of two formulated products, fluroxypyr (60 g ae/L) + triclopyr (180 g ae/L) and fluroxypyr (80 g ae/L) + picloram (80 g ae/L) against selected woody and herbaceous weeds. These two herbicide products provided control of weeds including honey locust, black locust, prickly pear, prickly ash, wax myrtle, osage orange, multiflora rose, blackberry, elm, Chinese tallowtree, ironweed, goldenrod, and sericea lespedeza that was comparable or superior to commercial herbicide standards. The desired level of control was usually achieved with less active ingredient applied compared to the commercial standards.

INVESTIGATING THE MOLECULAR BASIS FOR GLYPHOSATE RESISTANCE IN RIGID RYEGRASS AND GOOSEGRASS. Scott R. Baerson, Kenneth J. Gruys, Gerald M. Dill and Stephen O. Duke, Research Scientist, USDA-ARS, Oxford, MS 38677 and Monsanto Company, St. Louis, MO 63167.

The spontaneous occurrence of resistance to the herbicide glyphosate in weed species has been an extremely infrequent event, despite over 20 years of extensive use. Nevertheless, in recent years several apparent cases of evolved resistance have emerged, raising new possibilities regarding potential resistance mechanisms in weeds. Glyphosate-resistant rigid ryegrass and goosegrass represent the first two confirmed cases, and have been the most extensively studied at the molecular level. The results of detailed molecular and biochemical studies working with specific resistant biotypes of these species will be presented.

WATERHEMP RESISTANCE TO GLYPHOSATE: FACT OR FICTION? Reid J. Smeda and Christopher L. Schuster, Assistant Professor and Graduate Research Assistant, Department of Agronomy, University of Missouri, Columbia, MO 65211.

The adoption rate of glyphosate-resistant soybean (+70% in Missouri in 2002) has placed significant pressure for the selection of glyphosate-resistant weeds. To date, our group has identified potentially resistant common waterhemp near Monticello, MO and Sutter, IL. For both populations, there was no history for extensive POST application of glyphosate leading up to the identification of plants that survived field application rates (0.84 kg ae/ha).

Research to determine the extent of potential resistance has proven challenging, due to the low percentage of surviving plants in the general population. Seed were collected from plants located at each site, and put through two generations of selection with glyphosate (0.84 kg/ha). Seed from the original, first, and second generation for the Monticello, Sutter, and a known glyphosate sensitive (Bradford) population were screened in the greenhouse in both the summer and the winter to determine the relative percent of plants with little or no injury (0 to 35%). Visual evaluation of plants 2 weeks after treatment showed that winter screened plants surviving for the Monticello, Sutter, and Bradford populations ranged from 13.4 to 15.9%, 7.0 to 13.0%, and 0.2%, respectively when averaging over the original, first and second generation seed. However, for summer screened plants, survival for the Monticello, Sutter, and Bradford populations ranged from 0.2 to 1.4%, 0.3 to 0.9%, and 0%, respectively when averaging over the original, first and second generation seed. Recent screening has determined that third generation selected plants also exhibit a low percentage of plants that survive rates of glyphosate recommended for control.

Variability in the percentage of common waterhemp from Monticello and Sutter to survive when challenged with glyphosate has led to asexual propagation of shoot cuttings. Shoot cuttings from common waterhemp plants that survived 0.84 kg/ha glyphosate were propagated in liquid growth media, then transferred to soil media in pots. Cloned plants were treated at 12 cm with 0 to 3.36 kg/ha glyphosate. At 2 weeks after treatment, 25 and 31 of 36 plants from Monticello and Sutter, respectively, initiated new growth at glyphosate rates $\geq$ 0.84 kg/ha. Only 1 of 24 plants from the Bradford population survived. Both the Monticello and Sutter common waterhemp plants exhibit initial injury to glyphosate, but even plants treated with 3.36 kg/ha survived and formed reproductive structures

GLYPHOSATE RESISTANT WATERHEMP IN IOWA. Micheal D. K. Owen, Professor, Agronomy Department, Iowa State University, Ames, IA 50011.

Research conducted at Iowa State University demonstrated that individual common waterhemp plants within populations are resistant to glyphosate. Furthermore, all common waterhemp populations investigated, including a pristine (never under agricultural production) population from Ohio demonstrated variable response to glyphosate. Interestingly, the agricultural populations demonstrated less variable response than the non-agricultural population. Divergent recurrent selections resulted in a 3.5 fold increase in resistance. However, after 2 selections, while the frequency of the resistance increased within the population, there was limited segregation within the material and no stable homozygous resistant line was identified. This suggests that while the trait for glyphosate resistance is heritable, it is likely a polygenic characteristic. As common waterhemp is dioecious, and the genes controlling the glyphosate resistance have yet to be identified, it is impossible to provide growers with an accurate prediction as to how quickly populations will shift from sensitive to resistant. Furthermore, the specific mechanism(s) by which common waterhemp is resistant to glyphosate must be identified.

Regardless, sufficient information has been generated by weed scientists to suggest that common waterhemp populations can evolve resistance to glyphosate. Thus, growers need to consider how crop management practices impact the evolution of glyphosate resistance. It is obvious that the use of glyphosate-resistant soybean has contributed to the common waterhemp problem. Given the widespread adoption of glyphosate-resistant soybean and the multiple in-crop applications of glyphosate, considerable selection pressure for glyphosate resistance in weed populations has been imparted upon weed communities. Furthermore, the anticipated adoption of glyphosate-resistant corn hybrids will increase the selection pressure for glyphosate resistance. Should growers thus change management systems in order to delay the evolution of glyphosate resistance?

The use of glyphosate and GM crops has provided growers with a reportedly inexpensive and reasonably consistent weed management program. While the risk of glyphosate resistant common waterhemp biotypes is implicit in the system, other risks exist for a glyphosate-based crop production system. These risks include glyphosate drift from the multiple applications, concern for the marketability of the GM crops, lack of clear economic return on investment, yield differences compared to non-GM crops, pollen drift from GM maize, and other socio-economic concerns. Nevertheless, growers appear to be convinced that glyphosate-based crop production systems are in their best economic interest. The author suggests that this attitude is primarily the result of the presumed simplicity and consistency of the glyphosate-based systems.

Alternative weed management strategies exist that will delay the evolution of glyphosate-resistant common waterhemp. The inclusion of other herbicides and the use of mechanical tactics have considerable value in managing the evolution of glyphosate resistance. However, despite the risks that glyphosate-based crop production systems have, growers apparently not deemed these risks significant and continue to use glyphosate and glyphosate-resistant crops. It is difficult for extension weed scientists to make recommendations that growers use other herbicides and crop production strategies when that recommendation is based solely on the anticipated evolution of glyphosate-resistant common waterhemp populations, particularly when the speed of the population shift cannot be predicted and the alternative strategies result in the grower accepting more risk.

SYNGENTA'S RECOMMENDATIONS ON GLYPHOSATE RESISTANCE MANAGEMENT.

Dirk C. Drost and Chuck Foresman, Head, Development Planning and Technical Brand Manager, Syngenta Crop Protection, Inc., Greensboro, NC 27419-8300.

Syngenta Crop Protection is committed to the proper use, stewardship and performance of glyphosate herbicides, including its own proprietary brand of glyphosate (Touchdown™). Glyphosate resistance in weeds, now in its early stages in the U.S., presents a threat to the effectiveness and commercial viability of glyphosate and glyphosate-tolerant cropping systems. These systems have been widely adopted in soybeans and cotton; their benefits include efficacy, cost savings, simplicity and reduced environmental impact.

Three weed species have been reported resistant to glyphosate in the U.S., present in at least 8 states. Resistant horseweed (marestail) spread to over 500,000 acres of cropland in 2002. Tolerant or resistant waterhemp in the Midwest is an increasing concern.

Syngenta recommends making no more than two applications of glyphosate per two-year period in corn and soybean cropping systems. In cotton, Syngenta recommends that growers not exceed three applications of glyphosate per season. In all cropping systems, glyphosate should be rotated with other herbicides, full rates of glyphosate should be used, and weed escapes should not be allowed to produce seed or vegetative propagules.

Many farmers believe industry will bring new, effective replacements for glyphosate to the market; however, because of increasing development costs and regulatory hurdles this is not a realistic expectation. Economics and regulatory pressures will also force some older herbicides off the market, meaning fewer alternatives for weed control in the future. Where glyphosate-resistant weeds become established on cropland, land values (rental and sale) may be reduced. With some exceptions, industry and the university/extension community do not appear to be making a high-profile issue out of glyphosate resistance at this time. University weed scientists in particular can play a uniquely powerful role in educating growers and encouraging behaviors that conserve glyphosate as a resource in agriculture. The time frame for action is immediate; delaying actions will make this threat more difficult or impossible to manage.

A REGIONAL PERSPECTIVE ON GLYPHOSATE RESISTANCE MANAGEMENT. Christy L. Sprague, Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

As acres of glyphosate-resistant crops increase yearly, there is a growing concern about the development of glyphosate-resistant weed species. World-wide there are currently four weeds that have developed resistance to glyphosate; horseweed, goosegrass, Italian ryegrass and rigid ryegrass. In August of 2002, a survey consisting of several questions addressing attitudes on glyphosate resistance was sent out to weed scientists in the North Central Region. Responses came back from 14 states from as far west as Idaho to as far east as Pennsylvania. The first question asked the participants if there were any glyphosate-resistant weed species in their state. At the time of the survey all participants responded NO, with some caveats. First, most responses had the qualifier not that they were aware of, or what they would call RESISTANT from the WSSA definition of resistance. However, there are few species such as waterhemp with increasingly variable control observed from glyphosate applications. In addition, after this survey a population of glyphosate-resistant horseweed has been confirmed in Indiana. The second set of questions addressed the concern for glyphosate resistance in their state, by weed scientists, dealer/applicators, and growers. Throughout the region over 76% of weed scientists indicated that glyphosate resistance was of moderate to great concern to them, they felt that 75% of dealer/applicators thought it was of moderate concern, and less than 20 and 50% of growers thought it was of great and moderate concern, respectively. The last question focused on if there were any and what were the current recommendations in your state to delay or deal with glyphosate resistance. Ninety-five percent of the states indicated that they had recommendations in place for herbicide resistance. All of these recommendations started with the "*Guidelines on how to minimize the risk of herbicide-resistant weeds*" from the 1995 WSSA newsletter. However, only 25% of these responses indicated that there were additional recommendations specific for glyphosate resistance. Through this survey there were several questions raised on how much glyphosate is enough and how should we approach management of weeds that look like good candidates for glyphosate resistance. It is apparent that this issue of glyphosate-resistant weeds will continue to be a hot topic for years to come.

STATUS OF EPA LABEL GUIDANCE PROPOSAL ON DRIFT. Robert E. Wolf, Extension Specialist, Biological and Agricultural Engineering, Kansas State University, Manhattan, KS 66506.

The incidence and impact of spray drift has been and continues to be of concern. The Environmental Protection Agency (EPA) has responsibility to ensure that pesticide use does not cause unreasonable adverse effects to human health and the environment. As a way for the EPA to broaden its understanding of the science and predictability of spray drift new studies were requested in the process of registration or reregistration of crop protection products by the manufactures.

In 1990, the Spray Drift task Force (SDTF) was formed in response to the EPA's spray drift data requirements. The SDTF is a consortium of 38 agricultural chemical companies that spent approximately eighteen million dollars to support the reregistration of nearly 2,000 existing products and the registration of future products. Aerial, ground, air blast, and chemigation field studies were conducted establishing a drift database (40 reports) for the EPA. Computer models predicting drift and risk assessment are being developed from the database.

In 2001, the EPA developed draft document (PR Notice – OPP-00730) regarding labeling guidance for the purpose of informing pesticide registrants, applicators and other individuals responsible for pesticide applications with improved and more consistent product label statements for controlling pesticide drift. Public comment regarding any aspect of the PR notice was sought by the EPA for a period of 90 days which was later extended two more times.

More than 5000 comments were received from many public and private sectors, for and against, either in part or totally. Many letters were originated by various trade organizations. The EPA has since met with many major agribusiness trade groups to help each other understand the issues. Most of the responses were against the proposed 'zero tolerance', '10 MPH' wind limit, and the '4 and 10 foot' boom height limits for ground and aerial respectively. Most thought the proposal was completely unworkable and some felt the proposal had not gone far enough.

The EPA is planning to hold public 'listening' sessions during the winter 2002 at a few selected locations around the country. At the time of this writing the locations and dates these sessions have not been announced. Upon completion of the listening sessions the EPA plans to bring everything together that they have read and heard and draft a revised proposal for comment. This is expected to take place 2003.

In the meantime, the EPA continues to make decisions regarding labeling as new registrations applications come in or they complete reregistration of older products. Registrants have four options for submitting: (1) go with current draft labeling; (2) propose something else that is at least as protective that is acceptable; (3) go with labeling previously required under a RED for that pesticide; (4) go with old standard – "Do not allow drift".

For more information about the EPA's view on spray drift and to monitor the progress of the developments with this issue link to following web sites.

http://www.epa.gov/pesticides/citizens/spraydrift.htm

http://www.epa.gov/pesticides

ASAE S-572 DROPLET SIZE CLASSIFICATION STANDARD. Robert E. Wolf, Extension Specialist, Biological and Agricultural Engineering, Kansas State University, Manhattan, KS 66506.

The American Society of Agricultural Engineers (ASAE) is a professional and technical organization, of members worldwide, who are dedicated to the advancement of engineering applicable to agricultural, food, and biological systems. ASAE Standards are consensus documents developed and adopted by the society membership to meet the standardization needs within the scope of the society. Standard S-572 (Spray Nozzle Classification by Droplet Spectra) was developed by the ASAE Pest Control and Fertilizer Application Committee; approved by the Power and Machinery Division Standards Committee; and adopted by the society in August 1999.

The purpose of this standard is to define droplet spectrum categories for the classification of spray nozzles, relative to specified reference fan nozzles discharging spray into static air or so that no stream of air enhances atomization. The purpose of the classification is to provide the nozzle user with droplet size information primarily to indicate off-site spray drift potential and secondarily for application efficacy.

Generally the standard is based on spraying water through the reference nozzles and the nozzles to be classified. Nozzle manufacturers that intend to market spray tips will need to test their nozzles against the reference tips and should be measured with a laser-based instrument. The manufacturer can conduct the testing or have it done in an approved testing lab. The standard sets forth the guidelines for completing the test. Droplet spectra measurements for reference nozzles and nozzles being classified shall be performed with the same: instrument; measuring method; sampling technique; scanning technique; operator; and in a similar environmental condition.

Classification categories, symbols, and corresponding color codes are as following: **Very Fine (VF, red); Fine (F, orange); Medium (M, yellow); Coarse (C, blue); Very Coarse (VC, green); and Extremely Coarse (XC, white)**. The reference flow rate and operating pressure are specified for each reference nozzle because droplet size spectra from pressure atomizers are affected by flow rate and operating pressure. The included angle of the fan spray is also specified.

Future product labels will provide droplet spectra information and classification categories to guide applicators in setting up and calibrating sprayers for use in applying crop protection materials. This information will also be useful in handling complaints regarding misapplication which could include reduced efficacy and drift.

For additional information about S-572, link to Standards on the ASAE web site at:

http://www.asae.org/

PULSE WIDTH MODULATION FOR DROPLET SIZE CONTROL. Troy C. Kolb, Dr. D. Ken Giles and Jeffrey J Grimm, Field Engineer, Capstan Ag Systems, Topeka, KS 66603, Professor and Associate Development Engineer, Biological and Agricultural Engineering Department, University of California, Davis, CA 95161, Field Engineer, Capstan Ag Systems, Topeka, KS 66603.

Chemical pesticides are traditionally applied using electronic rate controllers to maintain application rates while allowing operators to vary the speed of the spray equipment. Traditional rate controllers vary the flow to match speed changes by varying the pressure, which in turn cause changes in droplet size, changes in efficacy and changes in drift potential.

Blended pulse spray systems utilizes an individual solenoid valve at each spray nozzle and uses the pulse width modulation technique to vary flow independent of pressure and speed. When coupled with a conventional rate controller, target application rate, pressure and droplet size can be set and maintained through an 8:1 speed range. Chemical efficacy is improved since the pressure and droplet size is maintained throughout the entire field. Operators can also minimize their drift potential, since they can adjust pressure and droplet size independent of rate and speed while applying.

OTHER APPLICATION EQUIPMENT TECHNOLOGIES TO IMPROVE EFFICACY AND MINIMIZE DRIFT. Robert E. Wolf, Extension Specialist, Biological and Agricultural Engineering, Kansas State University, Manhattan, KS 66506.

Several application equipment technologies have been developed to assist in the minimization of spray drift. The most popular and least costly to the industry has been in the design of spray tips. Most all manufactures have designed new tips with the emphasis on improved droplet size control to enhance efficacy and minimize drift potential. Chamber and venture style tips have been the most successful with this effort.

Two additional technologies have shown moderate success with drift minimization. One, air-assisted boom sprayers, uses a high velocity air stream channeled along the boom to assist the spray into the target. Research data will support improved deposition, but unless used in a canopied target the excess air velocity has potential to increase spray drift. The second involves the use of an electrostatic boom sprayer that will create and distribute electrically charged spray droplets into the target. The spray droplets are opposite polarity of the plant material and are attracted into the canopy. Electrostatic sprayers have proven more acceptable for increasing coverage in the canopy than for reducing the incidence of spray drift. For each, the additional cost added to the spray equipment has been a limiting factor in the adaptation of this technology.

The use of optical sensors to actuate spray tips in combination with individual row hoods can be an effective tool in reducing spray drift. By design the system only sprays a detected weed, and since it is not spraying all the time it is most effective for drift control because it is reducing the amount of pesticide being applied. However, in combination with improper tip selection and high pressures this technology would not be very effective.

Spray hoods and shields also have proven successful for reducing spray drift. Proper design is very critical for hoods to be beneficial. Hoods are typically designed to completely cover the boom while shields are usually placed in front or behind the boom and act strictly to shield the boom from wind. Field conditions, size and added weight to modern agricultural spray systems has limited the adaptation of this technology.

As future application guidelines regarding increased efficacy and spray drift minimization are established, more technologies will be developed and adapted regardless of cost. These developments will require sound research to support adaptation.

FLUMETSULAM + CLOPYRALID IN COMBINATION WITH REDUCED RATES OF MESOTRIONE FOR POSTEMERGENCE WEED CONTROL IN FIELD CORN. Sarah Taylor-Lovell*, Jon M. Babcock, Scott C. Ditmarsen, Mark A. Peterson, Larry G. Thompson, Field Research Biologists, Dow AgroSciences, Indianapolis, IN, 46268.

Eight trials were conducted across the Midwest US in 2002 to determine weed efficacy and crop tolerance resulting from postemergence applications of the premix clopyralid + flumetsulam (Hornet WDG[1]) at 144 g ae/ha tank-mixed with various rates of mesotrione (Callisto) with or without atrazine at 280 g ai/ha. The mesotrione rates used in the tank mix included 0, 8.8, 17.5, 26.3, 35, or 52.5 g ai/ha. All treatments contained COC at 1.0% v/v and 28% UAN at 2.5% v/v. Trials were located in fields containing at least one of the following small-seeded broadleaf species: common waterhemp, pigweed species, common lambsquarters, and Eastern black nightshade, in addition to other large-seeded broadleaf weeds. To reduce the pressure from grass species, most fields were chosen with low indigenous grass populations. On sites where grass populations were higher, metolachlor was applied preemergence at a 1/3X rate or sethoxydim resistant corn was planted to allow a postemergence application of sethoxydim for grass control. These methods reduced grass pressure with minimal impact on broadleaf populations.

All treatments demonstrated acceptable corn tolerance (less than 10% injury) at all rating times and locations. The clopyralid + flumetsulam premix alone provided greater than 90% control of common cocklebur, common sunflower, velvetleaf, and Venice mallow at 4 and 8 weeks after application. The addition of mesotrione at 8.8 g ai/ha plus atrazine at 280 g ai/ha improved control of common lambsquarters and eastern black nightshade to over 95%. Mesotrione at 26.3 g ai/ha + atrazine in combination with clopyralid + flumetsulam controlled common waterhemp (including a triazine-resistant population) and other pigweed species greater than 95% through the duration of the studies. Data from these trials indicate mesotrione at 26.3 g ai/ha + atrazine at 280 g ai/ha used in combination with clopyralid + flumetsulam will provide control of a wide range of broadleaf weeds.

[1] Trademark of Dow AgroSciences, LLC.

POSTEMERGENCE WEED CONTROL WITH NICOSULFURON + RIMSULFURON + MESOTRIONE MIXTURES IN CORN. Chris M. Mayo, Helen A. Flanigan and David W. Saunders, Development Representatives and Product Development Manager, DuPont Crop Protection, Johnston, IA 50131

In field trials the 2:1 premix of nicosulfuron and rimsulfuron applied at 0.56 ozai/acre provided excellent postemergence control of grass and some broadleaf weeds in field corn. The addition of mesotrione at 0.75–1 ozai/acre provided control of common lambsquarter, eastern black nightshade and velvetleaf. For control of common ragweed, common waterhemp and Palmer amaranth, atrazine at 4-12 ozai/acre was added to the tank mixture. Evaluations of this tank mixture taken 56 days after treatment from 35 sites, demonstrated residual control of common lambsquarter, common waterhemp, Palmer amaranth, velvetleaf and giant foxtail.

MESOTRIONE EVALUATIONS IN SWEET CORN FOR PROCESSING AND FRESH MARKET.
Stephen M. Sanborn and Michael D. Johnson, Syngenta Crop Protection, Greensboro, NC 27419.

Mesotrione (2-[4-methylsulfonyl-2-nitrobenzoyl]-1,3-cyclohexanedione) at 210 g ai/ha applied preemergence and 105 g ai/ha applied postemergence was evaluated for crop selectivity in sweet corn. Preemergence applications were made using a 40:400 g/l mesotrione:s-metolachlor co-formulation and a 32:320:120 g/l mesotrione:s-metolachlor:atrazine co-formulation. Effects of the postemergence spray additive treatments 1 % v/v crop oil concentrate (COC) + 2.5% v/v urea ammonium nitrate, 0.25 % v/v non-ionic surfactant (NIS) + 2.5% v/v urea ammonium nitrate (UAN), and 1% v/v COC were evaluated. Also, a postemergence tank mix of 105 g ai/ha mesotrione + 280 g atrazine + 1 % v/v COC was tested. Sweet corn hybrids and trial locations were chosen based on their commercial importance in the processing and fresh market industries in the United States. Preemergence applications of 210 g ai/ha mesotrione in the two co-formulations in general were safe to all sweet corn hybrids tested. Few negative effects were detected of preemergence applications of mesotrione on sweet corn emergence, early season injury, or yield at harvest. Postemergence applications of mesotrione + COC and mesotrione + atrazine + COC were also safe to most hybrids tested. However, when COC + UAN or NIS + UAN was used as an additive, postemergence applications of 105 g ai/ha mesotrione caused significant injury (bleaching) in some hybrids. Sweet corn yields generally were not reduced following postemergence applications of mesotrione or mesotrione + atrazine, regardless of spray additive or observed injury level. Results of these studies indicate that mesotrione has good potential for weed control in sweet corn for the processing or fresh market industries.

Comparison of Mesotrione and Glyphosate Weed Control Programs in Corn. Terence M. Carmody and Michael D. Johnson, Research and Development Scientist and Technical Brand Manager, Syngenta Crop Protection, Greensboro, NC 27419

A new mixture of mesotrione (2-[4-methylsulfonyl-2-nitrobenzoy]-1,3-cyclohexanedione), *S*-metolachlor (2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl)acetamide) and atrazine (6-chloro-*N*-ethyl-*N*-(1-methylethyl)-1,3,5-triazine-2,4-diamine) (trade name Lumax) has been introduced by Syngenta Crop Protection. Mesotrione provides excellent control of most important broadleaf weeds in corn including velvetleaf, pigweed species, waterhemp species, common lambsquarters, common ragweed, jimsonweed, nightshade species, and Pennsylvania smartweed. The addition of *S*-metolachlor plus atrazine to mesotrione in a pre-packaged mix results in the control of a broad spectrum of annual grass and broadleaf weeds. Corn shows excellent tolerance to Lumax. Preemergence Lumax is compared to postemergence single and multiple glyphosate weed control timings.

EVALUATION OF ISOXADIFEN-ETHYL FOR ENHANCING CORN TOLERANCE TO FORAMUSULFURON AND VARIOUS TANK MIXTURES. 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.

A study was conducted in 2001 at the University of Illinois Crop Sciences Research and Education Center in Urbana to examine what effect the safener, isoxadifen-ethyl plus the herbicide foramsulfuron had on corn tolerance when tank-mixed with several postemergence corn herbicides. The herbicides tank-mixed with foramsulfuron plus isoxadifen-ethyl were dicamba plus diflufenzopyr, mesotrione, and dicamba. The use of a methylated seed oil (MSO) is not recommended with these herbicides, due to the potential for corn injury. We wanted to determine if isoxadifen-ethyl applications would safen corn from injury caused by these herbicides when used with a MSO. A corn hybrid sensitive to plant growth regulator herbicides was used in this study for maximum corn injury and plots were kept weed-free to eliminate any competition from weeds. Herbicide applications of dicamba plus diflufenzopyr with and without foramsulfuron plus isoxadifen-ethyl with MSO were applied to corn at the V1 growth stage. These combinations and all other herbicide combinations were applied at the V5 corn stage. Herbicides were applied as either 1 or 2X the labeled field use rates. Applications of the 2X rate of dicamba plus diflufenzopyr at the V1 growth stage injured corn 72%. The addition of the 2X rate of foramsulfuron plus isoxadifen-ethyl decreased injury to 37%. Yield reductions were 67 and 51% from these treatments, respectively. Applications of the 1 and 2X rates of dicamba plus diflufenzopyr plus MSO to V5 corn caused significant corn injury. The addition of foramsulfuron plus isoxadifen-ethyl resulted in significant decreases in corn injury. Yields from the 1 and 2X rates of dicamba plus diflufenzopyr were statistically different from the non-treated control. However, when foramsulfuron plus isoxadifen-ethyl was added yield was not different from the control. Similar trends were observed with the 1X rate of dicamba. The addition of foramsulfuron plus isoxadifen-ethyl to mesotrione applied with MSO did not reduce corn injury or increase yield. The addition of foramsulfuron plus isoxadifen-ethyl increased the safety of dicamba based products when applied with MSO.

COMPARISON OF DIFFERENT HERBICIDE MIXTURES WITH FORAMSULFURON + ISOXADIFEN. Jayla R. Allen*, Michael Weber, Gerald Hora, and Gary Henniger. *Product Development Manager, Technical Development Representatives, Bayer CropScience, Research Triangle Park, NC 27709.

Foramsulfuron(1-(4,6-dimethoxypyrimidin-2-yl)-3-(2-dimethylcarbamoyl-5-formamidophenyl-sulfonyl)urea) is a novel sulfonylurea herbicide for post-emergence use in corn. Foramsulfuron is effective against major grass weed species, as well as some broadleaf weeds. It is applied with the new Bayer CropScience safener, isoxadifen-ethyl (ethyl 5,5-diphenyl-2-isoxazoline-3-carboxylate). The trade name for foramsulfuron + isoxadifen is Option® and is formulated as a 35 WG (35% foramsulfuron) in a 1:1 ratio. Option® has a recommended use rate of 37 g a/ha and has the flexibility to be utilized in a wide variety of tankmixes and is applied with methylated seed oil and UAN or AMS.

Foramsulfuron was tested in a variety of herbicide programs across 17 midwestern locations. Included in these trials was a premix formulation of foramsulfuron & iodosulfuron & isoxadifen. The foramsulfuron & iodosulfuron & isoxadifen premix has been submitted for federal registration with the trade name Equip™. The formulation is a 32 WG containing 30% foramsulfuron, 30% isoxadifen, and 2% iodosulfuron.

Foramsulfuron was compared to foramsulfuron & iodosulfuron in pre/post programs, mid post, and with dicamba & diflufenzopyr as a tank mix partner mid post for crop tolerance and weed control. Treatments included isoxaflutole 53 g a/ha + atrazine 560 g pre followed by foramsulfuron 37 g post, isoxaflutole 53 g + atrazine 560 g pre followed by foramsulfuron & iodosulfuron 27 g post, foramsulfuron 37 g post, foramsulfuron + iodosulfuron 27 g post, foramsulfuron 37 g + dicamba & diflufenzopyr 98 g post, foramsulfuron & iodosulfuron 27 g post + dicamba & diflufenzopyr 98 g post, and nicosulfuron & rimsulfuron 39.5 g + mesotrione 70 g + COC + N post. All foramsulfuron and foramsulfuron & iodosulfuron treatments included methylated seed oil and nitrogen.

Pre fb post treatments provided >90% control of all grass weeds. Foramsulfuron provided grass control ≥ the commercial standard. Foramsulfuron did not require a tank mix partner for adequate control of velvetleaf, common sunflower and redroot pigweed. Foramsulfuron & iodosulfuron and foramsulfuron + dicamba + diflufenzopyr increased broadleaf weed control for common ragweed, giant ragweed, common lambsquarters, and morningglory species compared to foramsulfuron alone. Foramsulfuron and foramsulfuron & iodosulfuron required the tank mix of dicamba + diflufenzopyr for control of common waterhemp. All treatments provided >95% control for shattercane, common sunflower, and redroot pigweed.

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FORAMSULFURON + ISOXADIFEN - SUCCESSES AND LESSONS LEARNED FROM A LAUNCH YEAR. Bill Striegel*, Daren Bohannan, John Cantwell, and Jayla Allen, Technical Development Representatives. Bayer CropScience, Research Triangle Park, NC 27709.

Foramsulfuron (2-[[[[(4,6-dimethoxy-2-pyrimidinyl)-amino]-carbonyl]amino]sulfonyl]-4-(formylamino)-N,N- dimethylbenzamide) is a novel sulfonylurea herbicide for post-emergence use in corn. Foramsulfuron is effective against major grass weed species, as well as some broadleaf weeds. It is applied with the new Bayer CropScience safener, isoxadifen-ethyl (ethyl 5,5-diphenyl-2-isoxazoline-3-carboxylate). The trade name for foramsulfuron + isoxadifen is Option® and is formulated as a 35 WG (35% foramsulfuron) in a 1:1 ratio with isoxadifen. Option® has a recommended use rate of 0.033 lb ai/A, has the flexibility to be utilized in a wide variety of tankmixes and is applied with methylated seed oil plus UAN or AMS.

Option® received EPA approval for use on March 27, 2002. Nearly 1.1 million acres of corn were treated in 2002. The majority of the acres treated with Option® were tank mixed with various herbicide partners to complete the spectrum of control of broadleaf weeds. Most common tank mix partners were dicamba products, atrazine, flumetsulam + clopyralid, or primisulfuron + prosulfuron. Product performance was tracked with less than 4% of treated acres receiving performance calls for weed control and less than 0.4% of the treated acres receiving calls for crop response.

Excellent crop safety was exhibited and crop response was minimal because of the proprietary safener isoxadifen-ethyl that is formulated with foramsulfuron. Previous research has shown that isoxadifen-ethyl reduces foramsulfuron phytotoxicity in corn by increasing the rate of foramsulfuron degradation[1]. Isoxadifen-ethyl has also been shown to reduce phytotoxicity of several broadleaf herbicide partners.

Several proposed label changes have been submitted to the EPA as a result of the experiences learned during the 2002 launch season. Included in the proposed changes will be the addition of the grass weeds reed canarygrass, smooth brome, downy brome, Italian ryegrass, and orchardgrass. Specific guidance will be included for making applications via drop nozzles to corn at a maximum V-8 stage of growth with nozzles directed to avoid application to the corn whorl. Additionally, the maximum application height for giant foxtail and wild oat will be increased from three to six inches. Several tank mix partners are proposed to be added for 2003.

[1]Chad Effertz*, Ken Pallett, Richard Rees., 2001. THE EFFECT OF ADJUVANT ON FORAMSULFURON AND ISOXADIFEN-ETHYL PERFORMANCE. In Proceedings of the North Central Weed Science Society, Vol. 56.

EVOLUTION OF ISOXAFLUTOLE USE PATTERNS IN CORN. George S. Simkins, David J. Lamore, Kevin K. Watteyne and Mark A. Wrucke, Technical Service Representatives and Northern Technical Service Manager. Bayer CropScience, Research Triangle Park, NC 27709

The isoxazole herbicide family was discovered by Rhone-Poulenc in 1989. The development of isoxaflutole (RPA201772) for commercial use commenced in 1992. This compound has broad-spectrum activity on broadleaf and grass weeds. The absorption of this compound is through the roots, shoots and leaves. It has weed control activity when applied preplant, preemergence and postemergence.

Isoxaflutole (IFT) received its US registration for use in Field corn in 1998. Since its introduction in 1999 use has increased to over six million acres in 2002. In the introductory year (1999) problems were experienced with IFT causing crop injury on a significant number of the fields treated with this product. Of the three million acres treated with IFT 442,000 acres had some degree of corn injury. The reported reasons for crop injury included: excessive use rates, variable soils, mixing problems, inaccurate application, poor agronomic practices and adverse weather conditions. In order to mitigate the problems encountered in 1999, Rhone-Poulenc Ag Company made major changes in the product label which included: rate recommendations based on three general soil classifications, new mixing and loading instructions, improved application techniques and equipment recommendations. In addition to these changes considerable effort was made to educate growers and applicators on how to utilize IFT effectively while minimizing the potential for crop injury. Crop response resulting from IFT applications in subsequence years has declined to approximately 1% of the treated acres. Most of the problems encountered with mixing the IFT formulation in 1999 were due to the dense characteristics of its dry granule, which required adequate wetting to disperse the product in water or liquid fertilizer. To overcome this problem Rhone-Poulenc Ag Company developed a flowable formulation that readily mixes in water and liquid fertilizer, and has weed control activity similar to the dry granule formulation. In 2001 the flowable formulation was introduced to the market place.

Most isoxaflutole is applied preemergence in corn. Because of short interval between planting and corn emergence, combined with adverse weather conditions, the number of acres that may be treated preemergence often may be limited. Comparisons of IFT applied at different timings have shown that preemergence is the most effective method of using IFT in a one-pass program. Shallow incorporated isoxaflutole, especially in tank-mixes, is effective and may have the advantage under dry soil conditions, or when the carrier is liquid fertilizer. Preplant surface applied IFT treatments also provide effective burndown as well as residual weed control. Rates may have to be increased to insure adequate residual activity.

Mesotrione is a new active ingredient that exhibits a mode of action similar to that of IFT. Weed control efficacy of package-mix formulations of mesotrione, metolachlor and/or atrazine is similar to isoxaflutole, tank-mixed with atrazine. The residual activity of mesotrione combinations in some cases is inferior to that provided by IFT combinations, and lacks postemergence of most grasses.

CAMIX: NEW MESOTRIONE BASED PREEMERGENCE HERBICIDE FOR CORN. Dain E. Bruns, Michael D. Johnson, and Brett R. Miller, Research and Development Scientist, Technical Brand Manager, and Research and Development Scientist, Syngenta Crop Protection, Greensboro, NC 27419.

Camix 3.7 SC, a combination of mesotrione [2-(4-mesyl-2-nitrobenzoyl)-3-hydroxycyclohex-2-enone] and *S*-metolachlor [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide], has been developed by Syngenta Crop Protection for preplant, preemergence, and burndown applications in field, seed, and silage corn at rates up to 2.2 lb/A. Mesotrione, an inhibtor of p-hydroxyphenol pyruvate dioxygenase and carotenoid synsthesis in susceptible species, provides excellent control of the most important broadleaf weeds in corn including velvetleaf, pigweed species, waterhemp species, common lambsquarters, common ragweed, jimsonweed, nightshade species, and Pennsylvania smartweed. The addition of *S*-metolachlor to mesotrione in pre-packaged mixture results in the control of a broad spectrum of annual grass and broadleaf weeds. Corn shows excellent tolerance to the pre-packaged mixture of mesotrione and *S*-metolachlor.

LUMAX CORN HERBICIDE: PRODUCT INTRODUCTION AND TECHNICAL POSITIONING.

Scott E. Cully, Michael D. Johnson, and Brett R. Miller, Research and Development Scientists and Tehcnical Brand Manager, Syngenta Crop Protection, Greensboro, NC 27419.

Lumax™ 3.95 SC herbicide is a pre-packaged mixture of Mesotrione with *S*-metolachlor and Atrazine from Syngenta Crop Protection. This new mixture was developed for preplant, preemergence and early postemergence use in corn. Lumax herbicide applied prior to weed emergence provides excellent control of most important broadleaf and grass weeds in corn including velvetleaf, pigweed species, waterhemp species, common lambsquarters, common ragweed, jimsonweed, nightshade species, Pennsylvania smartweed, foxtail species, barnyardgrass, fall panicum, broadleaf signalgrass and crabgrass . Corn shows excellent tolerance to Lumax herbicide.

ONGOING INVESTIGATIONS INTO GLYPHOSATE RESISTANT HORSEWEED: RESISTANCE MECHANISM STUDIES. Gregory R. Heck, Sophia Y. Chen, Tommy Chiu, Paul Feng, Jintai Huang, Chris S. Hubmeier, Youlin Qi, R. Douglas Sammons, Monsanto Company, 700 Chesterfield Village Parkway, St. Louis, MO 63198.

Genetic studies have continued on glyphosate resistant horseweed (*Conyza canadensis*) isolated from the Delmarva region. Reciprocal F1 crosses between sensitive (S) and resistant (R) biotypes were monitored for growth reduction over a glyphosate rate titration. Relative to the R parent, both crosses transmit the trait equally and in dominant fashion revealing a nuclear-encoded basis for resistance. F2 analysis of 200 individuals/rate (using a titration series, 0.42 – 3.38 kg ae/ha) showed a 3:1 segregation (R:S) indicating a single dominant locus accounts for the majority of resistance. F1 backcrosses [S x (S x R)] with 50 individuals/rate confirmed a single dominant locus with a 1:1 segregation ratio.

Analysis of the S biotype showed additional genetic variation within the sensitivity of individuals from this biotype. An approximately 2X difference in sensitivity was apparent in the S1 (most sensitive lineage, controlled at 0.25X field rate or 0.21 kg ae/ha) vs. S2 (less sensitive lineage, controlled at 0.5X) lineages. This differential in response could be transmitted in a dominant or semi-dominant fashion to F1 progeny (S1 x S2). F2 progeny are being examined and crosses to the R parent (S2 x R) for allelism testing have been completed.

Three EPSPS genes have been isolated from horseweed, EPSPS 1-3. An active site variant, P106T (proline typically found at the 106 position is substituted with threonine), in EPSPS-3 was identified in both S and R biotypes from Delaware. This variant would be predicted to have some glyphosate resistance based on biochemical studies of petunia and maize EPSPS active site mutants, however, it has not been characterized in vitro. Surveys of biotypes across the country (including: R biotype from DE and TN; and S biotypes from CA, DE, IA, MI, MO, NC, and WA) all had the EPSPS-3 gene bearing P106T. This form of EPSPS is thus a feature of the species and not unique to resistant biotypes (a novel observation for the well-conserved EPSPS active site of higher plants). In addition, an isolate from Walla Walla, WA also had a M104L change (i.e. M104L and P106T both in EPSPS-3) relative to other horseweed isolates. We are currently expressing EPSPS-3 for in vitro biochemical characterization. It is unclear how EPSPS-3 could contribute significantly to resistance since it is found in both biotypes. Minimally, EPSPS-3 cannot function independently from the genetically defined locus to convey resistance.

Previously, we had shown that resistance does not appear to be based on differential glyphosate uptake, glyphosate metabolism, differential gene expression of EPSPS, or amplification of EPSPS genes. One physiological distinction noted was differential translocation of glyphosate to roots. We confirmed this using a sub-lethal rate (0.026 kg ae/ha to minimize glyphosate toxicity effects on transport) of ^{14}C-glyphosate applied with a track sprayer. Although comparable amounts of glyphosate entered leaves, S lineages translocated approximately 2-fold more glyphosate to roots relative to R lineages. Even though we do not know how this differential is translated to the larger differential in whole plant resistance of R vs. S biotypes, it is a signature feature imparted by the resistance locus. Analysis of glyphosate resistant horseweed is continuing to fully understand the mechanism of glyphosate resistance.