FUTURE OPPORTUNTIES IN WEED SCIENCE: MY VIEWS. Dirk C. Drost, Head, Development Planning, Syngenta Crop Protection, Inc., Greensboro, NC 27419-8300

In the 1980's, perhaps few in the field of weed science would have predicted the coming upheaval from new technology and outside forces. Adapting to changes, such as industry consolidation, public environmental concerns and herbicide tolerant crop technology, has challenged many weed scientists. Some topical concerns, such as the control of invasive species, have generated new opportunities in the form of jobs and funding. These new areas of study are not, however, the only promising options for the future of weed science. The present paradigm will not alter the fact that our current level of agricultural productivity is dependent on herbicides for weed control. There will be a continuing need for expertise in weed control and herbicide technology. The advent of herbicide-tolerant crops has not altered the fact that expertise will be required to preserve and maintain this technology. One concern is the way the current support for new and on-going research impacts the training of weed scientists. A dialogue needs to begin on how many weed scientists we will need in the future and what skills they must have. The basics of agronomy, agricultural engineering, biochemistry, botany, horticulture, plant physiology, problem solving and production agriculture must remain an integral part of the weed science curriculum in order to continue serving core interest groups and the public overall. Controlling weeds is no longer a matter of simply applying herbicides. Weed scientists will continue to face the delicate but important task of helping farmers maintain or increase yields, while taking full advantage of new technology without abusing it. The next generation of weed scientists must also be trained in a cost-effective and efficient manner.

The key to the future lies in having open discussion now and in forming partnerships between academia and industry so that our planning for the future succeeds. It is essential that this planning take place. The field of weed science will require even sharper minds and more specialized training going forward because of the tremendous challenges presented by spreading herbicide resistance and the incredible leaps in technology made over the last decade. To meet these challenges, we must build a regional society with long-term stability and begin identifying and training the next generation of professionals who will affiliate with it. We must help the agricultural community preserve existing technology as we develop new weed control tools, even as we deal with the stresses of having fewer researchers, less funding and fewer active ingredients. Finally, we must seek out new public and private partnerships to address the needs of farmers and other end users for weed management.

I AM NOT A REAL WEED SCIENTIST BUT I PLAY ONE IN DC. Robert R. Hedberg, Director of Science Policy, Weed Science Society of America, Washington, DC 20002.

Weed science is an inclusive discipline with no significant barriers to entry. A person's individual choice to self-designate themselves as a weed scientist and affiliate themselves with the discipline has always been adequate to gain entry into this field. Once embarked in the discipline, hard work, dedication, a sense of duty and an observant eye have typically yielded success and recognition. This openness offers many benefits for the discipline, but it also has some drawbacks. Certainly, our willingness to include agronomists, botanists, entomologists, ecologists, pathologists, physiologists and numerous other specialties within our discipline and within our societies has added to the enormous achievements of the past half –century. Currently however ambiguity about prerequisite skills and training may pose problems for the discipline. With the growing federal concern about invasive plants, significant retooling of existing staff to work in this arena is likely, and such retooled staff may lack the fundamental training and experience necessary to implement comprehensive, effective and efficient weed research, education, management and regulatory programs. It is incumbent on our societies to work with federal agencies to identify the fundamental knowledge, skills and abilities that are necessary at different weigh points along this weed management - weed science continuum.

Just as specific weed science training and experience is highly desirable in the individuals who will lead and implement federal, state and local weed programs; weed scientists should strive to acquire specific policy, communication and management skills. Some of these skills may seem alien to a scientific mindset but are fundamental in the policy arena. Within our discipline, extension educators best exemplify the skills that will contribute to our success influencing public policy. Specific skills to emulate are empathy for audience needs and interests, the ability to tailor information to specific audiences, active pursuit of allies and partners, willingness to compromise and acknowledge different viewpoints, a sense of public service, enthusiasm for the subject matter and timeliness. Ultimately, the success of our discipline will depend in large part on public support that in turn deponds on public belief in us as individual citizen scientists and science ambassadors. This public support must be sought and earned at every point form the local to the national level.

HARVESTING TECHNIQUES FOR CUPHEA, A NEW OILSEED CROP. Dean Peterson, Joe Boots, Russ Gesch, and Frank Forcella, USDA-ARS, Morris, MN 56267.

Cuphea is a potential alternative oilseed crop that produces medium chain-length fatty acids (capric and lauric acids). These fatty acids are feedstocks for non-food products, such as lubricants and detergents, all of which currently are derived from imported coconut and palm kernel oils. Cuphea grows well in the upper Midwest of the United States, and it potentially could become a domestic source for medium chain-length fatty acids. However, harvesting this non-determinant crop remains a challenge. In particular, the best times and methods of harvesting to minimize cuphea seed shattering are unknown. To overcome these limitations, we tested a range of harvesting aids on 'PSR-23' of cuphea (*C. viscosissima* x *C. lanceolata*) in bulk-planted fields. In late August to early September when cuphea was at the mid-seed development stage, the following desiccants were applied in 3 m wide replicated plots: paraquat, glyphosate, sodium chlorate, and paraquat + sodium chlorate. Plots were combine-harvested about 1 wk after treatment. Additionally, 28 plots, each 1.5 x 5 m, were combined after being cut in mid August and drying in windrows for 1 to 7 wk.

Paraquat + sodium chlorate desiccated plants most rapidly and allowed quick combining that minimized seed losses due to shattering and chaff contamination of combined seeds. Windrowing for about 2 to 3 wk after cutting allowed plants to dry thoroughly, permitted efficient combining, and minimized seed losses. Thus, both desiccants and swathing can be used to increase the harvesting efficiency of this partially domesticated crop.

EFFECTS OF HERBICIDE AND SIMULATED TILLAGE ON WHEAT CURL MITE SURVIVAL AND WHEAT STREAK MOSAIC. Wenbo Jiang, Karen Garrett, Dallas Peterson, Thomas Harvey, and Robert Bowden, Graduate Research Assistant, Assistant Professor, Professor, Professor, and Adjunct Associate Professor, Kansas State University, Manhattan, KS 66506.

Wheat curl mite, the vector of wheat streak mosaic virus, often survives the summer on volunteer wheat plants. Mites that survive until fall may disperse to newly-planted winter wheat. To control the wheat curl mite, growers often apply post-harvest tillage or herbicide to kill volunteer wheat. The timing of this management is critical since killing volunteer wheat too late in the season may promote movement of mites to newly-planted wheat. The objectives of this research were to determine the effects of glyphosate, paraquat, and simulated tillage on wheat curl mite survival on wheat plants over time. In a series of greenhouse experiments, wheat plants grown in pots were infested with viruliferous mites. Three to four weeks after mite populations were introduced, plants were treated with glyphosate, paraquat, undercutting, or no treatment. Mite populations on each plant were counted over the next one to two weeks. Population size was compared to the control at each sampling date. Mite populations on plants treated with paraquat decreased from the beginning of the sampling period. The effect of undercutting (simulated tillage) on the mite population was similar to the effect of paraquat. Mite populations on plants treated with glyphosate increased up to three days after application and then decreased to approximately the same level as the paraquat populations by ten days after application. Control mite populations increased until day ten of the study and then decreased, probably because of plant damage caused by wheat streak mosaic virus. If glyphosate is used to manage wheat volunteers infested with wheat curl mite, it should be applied well before wheat is planted in fall.

HERBICIDE TOLERANCE IN CUPHEA: A NEW OILSEED CROP. Gary Amundson, Frank Forcella, and Russ Gesch, Engineering Technician, Research Agronomist, and Plant Physiologist, USDA-ARS, Morris, MN 56267.

Cuphea is a potential alternative oilseed crop that produces medium chain-length fatty acids (capric and lauric acids). These fatty acids are feedstocks for non-food products such as lubricants and detergents, which currently are imported in the form of coconut and palm kernel oils. Cuphea grows well in the upper Midwest of the United States and, therefore, is a potential domestic source of these fatty acids. However, weed management remains a challenge in cuphea, as the plant tolerates weeds very poorly. To overcome this limitation, we tested a wide range of soil-applied and POST herbicides on 'PSR-23' cuphea (*Cuphea viscosissima* x *C. lanceolata*) using a precision spray chamber and a temperature- and water-controlled greenhouse. Promising chemicals were subsequently field-tested on a clay loam soil at the Swan Lake Research Farm near Morris, MN. Before or immediately after cuphea was planted, PPI or PRE herbicides were applied in replicated strip plots. Once seedlings reached the 3-leaf stage, POST herbicides were applied in replicated strip plots perpendicular to the PPI-PRE plots. Cuphea tolerance to these treatments was scored 2 wks after the POST applications. Cuphea showed good tolerance to the following herbicides applied at rates labeled for soybean or corn: ethalfluralin PRE, isoxaflutole PRE, and mesotrione POST. Fair tolerance was shown to mesotrione PRE, trifluralin PPI, isoxaflutole PRE + mesotrione POST, ethalfluralin PRE + mesotrione POST, and imazethapyr POST. Although these herbicides do not control the entire spectrum of weeds found in the upper Midwest, they provide sufficient coverage to allow agronomic research to continue and initial stages of crop commercialization to begin.

EVALUATION OF AE F130060 WITH DIFFERENT ADJUVANT CLASSES FOR WILD OAT CONTROL AND SPRING WHEAT RESPONSE. Angela J. Kazmierczak, Kirk A. Howatt, and Michael C. Smith, North Dakota State University, Fargo, ND 58102 and Bayer CropScience, Sabin, MN.

The purpose of this study was to evaluate adjuvant enhancement of AE F130060 (proposed common name mesosulfuron) efficacy and crop response. Mesosulfuron is a sulfonylurea chemical compound that requires addition of an adjuvant for maximum efficacy. Experiments were conducted at two locations in 2003: Fargo, North Dakota and Sabin, Minnesota. The study consisted of an untreated control, an herbicide control with no adjuvant, and nine adjuvant treatments. Experiment design was randomized complete block with three replicates. Each herbicide treatment included mesosulfuron at 17.5 g ai/ha. Adjuvant classes included basic pH blend, non-ionic surfactant, silicone surfactant, petroleum oil concentrate, methylated seed oil, methylated seed oil basic blend, and fertilizer. Crop safety (7 and 14 DAT and preharvest) and wild oat control (14 DAT and preharvest) were evaluated, and wheat was harvested at physiologic maturity. Injury manifested as slight stunting that was evident throughout the entire season. Efficacy and yield data could not be combined, because of differences in wild oat population between the two locations. Treatments containing methylated seed oil increased mesosulfuron control of wild oat by as much as 85% while only increasing crop response by 5 percentage points 7 DAT. Only methylated seed oil plus 28% nitrogen increased injury from mesosulfuron 14 DAT. Mesosulfuron plus methylated seed oil and 28% nitrogen provided exceptional wild oat control compared with mesosulfuron alone, resulting in 28% greater wheat yield at Fargo compared with mesosulfuron alone.

USE OF PARAQUAT AS A HARVEST AID FOR CEREALS. Dennis E. Stamm, Thomas B. Threewitt, and Charles Foresman, Research Scientist, Research Scientist, and Technical Brand Manager, Syngenta Crop Protection, Greensboro, NC 27419.

University researchers in six states conducted trials in 2002 and 2003 that evaluated paraquat as a harvest aid in spring and winter wheat. Treatments included paraquat alone, paraquat tank mixed with 2,4-D or the DGA salt of dicamba, glyphosate treatments, and metsulfuron + 2,4-D. Application timings were: 10-14 day before harvest (dbh), approximately 7 dbh, and 3 dbh. Soil moisture at time of application influenced weed control. In the trials with adequate soil moisture, paraquat gave weed control in as little as 2 days. Under drier soil moisture conditions, weed control was reduced and the speed of control was slower. Paraquat alone or in tank mix with 2,4-D or the DGA salt of dicamba gave the best control of kochia, Russian thistle, common and slimleaf lambsquarter. Herbicide treatments did not reduce yields. In some of the spring wheat trials, grain moisture in the herbicide treated plots was lower than the untreated plots.

WINTER ANNUAL GRASS CONTROL IN IMIDAZOLINONE RESISTANT WHEAT WITH IMAZAMOX AND COMPETITIVE TREATMENTS. Mark M. Claassen and Dallas E. Peterson, Professors, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Genetic resistance to imidazolinone in wheat, identified by the Clearfield trade name, is being actively incorporated into varieties grown in the Great Plains. This resistance allows producers to use imazamox herbicide for wide-spectrum weed control in wheat, including that of troublesome grasses such as rye and bromus species. Field experiments were established in the fall of 2002 at Hesston and Manhattan, KS, to evaluate crop safety as well as efficacy of application times and rates of imazamox herbicide and imazamox tank mixes in comparison with sulfosulfuron, MKH 6561 and flucarbazone sodium.

Variety AP502 CL winter wheat was planted with 20-cm row spacing at each location in October. Fall treatments were applied after mid-November. Dormant treatments were sprayed in mid-February or March. Spring treatments were applied in late March. At application times, stage of development of wheat and weeds generally was more advanced at Manhattan than at Hesston. 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.

Fall herbicide treatments caused no meaningful injury to Clearfield wheat at Hesston, where late dormant applications of imazamox plus chlorsulfuron&metsulfuron, imazamox plus dicamba, and sulfosulfuron plus chlorsulfuron&metsulfuron caused minor injury in the form of slight stunting and/or chlorosis which dissipated with time. Several imazamox treatments caused minor stunting of wheat at Manhattan, with injury tending to be more severe when applied with methylated seed oil or when tank-mixed with chlorsulfuron&metsulfuron, especially in spring applications.

Cheat control with imazamox was only fair with fall treatments at Hesston, where limited fall cheat emergence and development occurred. There, fall application of imazamox with methylated seed oil or chlorsulfuron&metsulfuron each improved cheat control by 9%. All fall imazamox treatments gave good cheat control at Manhattan. Sulfosulfuron, MKH 6561, and flucarbazone sodium treatments in the fall provided very good to excellent cheat control at both locations. Dormant application of imazamox treatments gave good cheat control at Hesston, but at Manhattan, unless methylated seed oil was used as an adjuvant, resulted in only fair control of cheat. MKH 6561 and flucarbazone sodium in dormant applications were consistently very effective on cheat, while sulfosulfuron provided fair control at Manhattan and excellent control at Hesston. Spring application of imazamox resulted in fair cheat control that was significantly improved by increased rate, tank mix with dicamba, or use of methylated seed oil adjuvant. MKH 6561 and flucarbazone sodium in the spring completely controlled cheat, while sulfosulfuron was somewhat less effective and benefitted from chlorsulfuron&metsulfuron as a tank mix partner.

Downy brome control with imazamox treatments was good with fall, fair to good with dormant, and fair with spring application timings. Addition of methylated seed oil tended to enhance the efficacy of imazamox, while inclusion of dicamba or chlorsulfuron&metsulfuron as a tank mix partner tended to reduce the effectiveness of imazamox on downy brome. All other herbicide treatments gave unsatisfactory downy brome control.

Rye control was good to excellent with imazamox and poor or totally ineffective with all other treatments. Fall imazamox treatments were best with methylated seed oil adjuvant or with the higher application rate, but the addition of chlorsulfuron&metsulfuron or dicamba tended to reduce the level of rye control. Dormant application of imazamox was effective only with methylated seed oil. Rye control with all spring imazamox treatments was good to excellent.

Wheat yields were enhanced by weed control Manhattan. Most herbicide treatments significantly improved apparent wheat test weight, with average increases of 7.3 and 9.5 lb/bu at the two locations.

TRIBENURON-TOLERANT SUNFLOWERS: CROP PHYTOTOXICITY AND WEED EFFICACY.
James D. Harbour, Michael T. Edwards, Christopher M. Mayo, Robert N. Rupp, Eric P. Castner, and Larry H. Hageman, Field Development Representatives, DuPont Ag & Nutrition, Denver, CO, 80228, and DuPont Ag & Nutrition, Des Moines, IA, 50131.

Field research was conducted in KS, TX, SD, ND, NE, CO, and IL in 2002 and 2003 to determine efficacy and crop response when tribenuron was applied to 2-leaf (V2), 8-leaf (V8), and post-bud (R1) tribenuron-tolerant sunflower. Standard small-plot research techniques were used at all the research locations. Tribenuron was applied at 0.125, 0.1875, 0.25, and 0.5 oz ai/a to V2, V8, R1; and, each herbicide rate was applied sequentially to V2 then V8, growth-stage sunflower. Because of hybrid-line advances in 2003, phytotoxicity results are for only '03BM0024' hybrid data. Phytotoxicity at 7 DAA ranged from 0 to 18% and decreased to less than 5% at 42 DAA. Phytotoxicity was generally greater when tribenuron was applied to V2 or V2 then V8 sunflower (2 – 18%) than V8 or R1 sunflower (<1%). However, tribenuron-tolerant sunflower injury decreased to 4% or less by 42 DAA. Efficaciously, tribenuron controlled common lambsquarters regardless of herbicide rate or application timing; however, common purslane was not controlled by tribenuron. Kochia, palmer amaranth, redroot pigweed, Russian thistle, and puncturevine were controlled best with tribenuron applied sequentially to V2 then V8 sunflowers.

Field research was conducted in KS, SD, CO, and NE in 2002 and 2003 to determine efficacy and tribenuron-tolerant sunflower response to tribenuron and adjuvants. Adjuvants tested included non-ionic surfactant (NIS), crop oil concentrate (COC), modified seed oil (MSO), organosilicone/modified seed oil (OS/MSO), "Kinetic", and "Liberate". Tribenuron was applied at 0.125, 0.25, and 0.5 oz ai/a to approximately V8 sunflowers. Phytotoxicity, averaged across adjuvants, was less than 5% at 14 DAA and decreased to less than 1% by 29 DAA. Averaged across tribenuron rates, phytotoxicity , was not greater than 5% at 21 DAA and decreased to less than 2% by 39 DAA. Tribenuron efficacy, averaged across rates, was better with COC, OS/MSO, MSO, or NIS than with "Liberate" or "Kinetic".

Field research was conducted in SD, KS, ND, and WY in 2002 and 2003 to determine efficacy and tribenuron-tolerant sunflower response to various weed control programs currently used in the US. However, plants at the SD site in 2002 were severely drought stressed causing variable and unreliable results; thus, this study was dropped from the analysis. Pendimethalin, sonalan, and sulfentrazone were applied pre-emergence to tribenuron-tolerant sunflower, after which tribenuron (0.125 oz ai/a) was applied post-emergence to approximately V8 sunflower. Further, tribenuron (post-emergence) was applied without a pre-emergent herbicide for a POST-only herbicide treatment program. Phytotoxicity was less than 4% (14 DAA) regardless of herbicide treatment program. Weed control programs provided good-to-excellent control of kochia, Russian thistle, and puncturevine.

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

Weed management programs in corn include greater utilization of POST herbicides, some of which have little or no residual activity. Lack of residual herbicides is thought to contribute to a greater prevalence of winter annual weeds. This study was established in central and northeast Missouri to determine the impact of fall applied herbicides versus traditional spring programs for weed management in corn.

In early November of 2001 and 2002, rimsulfuron + thifensulfuron, rimsulfuron + thifensulfuron + tribenuron, rimsulfuron + thifensulfuron + simazine, simazine, tribenuron, imazethapyr + imazapyr, imazethapyr + imazapyr + simazine, flumetsulam + metribuzin or thifensulfuron + tribenuron were applied and compared to 2,4-D applied alone. Spring treatments included dimethamid + atrazine + glyphosate or glyphosate + atrazine. Henbit (*Lamium amplexicaule*) and common chickweed (*Stellaria media*) control exceeded 90% until early May for all fall applied residual herbicides. Common chickweed control was less than 60% with 2,4-D alone and henbit control was erratic. Corn was planted no-till in early May, and residual activity of fall applied herbicides was determined 2 weeks after planting (WAP) for giant foxtail (*Setaria faberi*) and common ragweed (*Ambrosia artemisiifolia*). Giant foxtail control ranged from 0 to 95% over sites and years, with the most consistent treatments being tribenuron + simazine, imazethapyr + imazapyr, and imazethapyr + imazapyr + simazine. These same treatments also resulted in 70-95% control of common ragweed. The most inconsistent treatments for control of winter annuals included simazine alone, flumetsulam + metribuzin, and thifensulfuron + tribenuron. To evaluate early season impact of weeds or weed residues on corn, all weeds were removed with nicosulfuron + rimsulfuron + mesotrione or imazethapyr + imazapyr. Across all site-years, the highest grain yield was measured in a fall applied treatment containing simazine in 3 of 4 experiments.

EFFECT OF POSTEMERGENCE APPLICATION TIMING ON CROP SAFETY OF NICOSULFURON PLUS RIMSULFURON MIXTURES IN CORN, Helen A. Flanigan, Eric P. Castner, Robert E. Etheridge and David W. Saunders, Development Representatives and Product Development Manager, DuPont Ag & Nutrition, Johnston, IA 50131.

Field studies were established in corn to assess crop response from applications of Steadfast (nicosulfuron + rimsulfuron) and various tank mixtures when applied to two, four and six leaf collar corn. To reduce the impact of environment at the time of herbicide application, planting dates were varied so a single application timing could be used. Crop response at seven days after treatment with Steadfast was comparable to Steadfast tank mixtures with atrazine, mesotrione or dicamba. Minimal differences in crop response were seen from applications made to various corn growth stages. Plant health at the time of herbicide application was the greatest determining factor in crop response.

HERBICIDE PROGRAMS FOR GLYPHOSATE RESISTANT CORN. J. Leslie Lloyd, Richard M. Edmund, Christopher M. Mayo, and David W. Saunders, Development Representatives and Product Development Manager, DuPont Ag & Nutrition, Johnston, IA 50131.

Studies were conducted at 17 locations in 2003 comparing herbicide systems in glyphosate tolerant corn. Glyphosate applied alone early post emergence was compared to tank mixtures of glyphosate and rimsulfuron and to tank mixtures containing glyphosate and metolachlor and glyphosate, metolachlor and atrazine. A standard tank mix of Steadfast (nicosulfuron + rimsulfuron), Callisto (mesotrione) and atrazine was included. Key weeds included giant foxtail, yellow foxtail, fall panicum, ivyleaf morningglory, and tall waterhemp. For season long weed control it was necessary to add a residual product to the glyphosate for control of both grass and broadleaf weed species. Rimsulfuron provided good residual control of many grass and small-seeded broadleaf species and improved the control of the glyphosate on several broadleaf species. For most weed and grass species the tank mix of Steadfast, Callisto and atrazine provided equal or superior season long control compared to treatments including glyphosate.

CORN RESPONSE TO MESOTRIONE AS AFFECTED BY SOIL INSECTICIDE APPLICATION METHOD AND RATE. Andrew J. Chomas, Michael R. Jewett, Christina DiFonzo, and James J. Kells, Research Technician, Department of Crop and Soil Sciences, Research Technician and Associate Professor, Department of Entomology, Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

A field trial was conducted in 2002 to examine the effect of insecticide type and mesotrione application rate on corn injury. Corn injury increased with increasing mesotrione rate. Corn injury from mesotrione at 0.21 kg ai/ha was 34, 19, and 13% in corn treated with terbufos, chlorpyrifos, and tefluthrin, respectively. Corn recovered rapidly from mesotrione injury with no measurable reduction in corn yield. A second study examined the effect of insecticide type, insecticide application rate, and insecticide application method on corn injury from mesotrione. Corn injury was greater in corn treated with terbufos than clorpyrifos. Injury from mesotrione was greater with terbufos applied at two times the typical rate. Corn injury was slightly higher when terbufos was applied in-furrow versus T-band. Corn injury from mesotrione did not reduce yield.

RESPONSE OF WOOLLY CUPGRASS TO TILLAGE, CORN PLANTING DATE AND HERBICIDES. James F. Lux, Damian D. Franzenburg, and Micheal D. K. Owen, Ag Research Specialists, and Professor, Agronomy Department, Iowa State University, Ames, IA 50011.

A field experiment was conducted in 2002 to evaluate the response of woolly cupgrass to tillage, corn planting date, and herbicides. Tillage, corn planting and herbicide applications were done on two dates; April 16, (D1) at or near initial woolly cupgrass emergence, and May 20, (D2) near or subsequent to maximum woolly cupgrass emergence. Acetochlor and isoxaflutole herbicides were applied preemergence each date at ½ and 1x recommended rates following planting. Each date included an untreated control. Emerged woolly cupgrass were counted prior to each tillage, planting and herbicide application date, and at 4 and 8 weeks. Visual estimates of percent corn injury and woolly cupgrass control were made at 4 and 8 weeks. Corn yields were determined.

Woolly cupgrass emergence in the untreated control had just begun on D1 with few seedlings/m-2 noted. However, emergence in the untreated control on D2 was nearly 1000 fold that of D1. Emergence in the untreated control at 4 and 8 weeks was significantly higher with D1 compared to D2. Further, emergence in the untreated control at 8 weeks following D1 was nearly 4 times higher than D2. In contrast, emergence in the untreated control at 8 weeks following D2 was one-tenth that of the initial number recorded.

Emergence of woolly cupgrass in the ½x and 1x acetochlor and isoxaflutole treatments applied D1 was significantly less at 8 weeks compared to that in the untreated control. Further, significantly fewer emerged in acetochlor 1x, isoxaflutole ½ and 1x treatments compared to acetochlor at ½x. All treatments, however, achieved poor control at 40 to 63%. Isoxaflutole at 1x was an exception and provided fair control at 76%. Emergence of woolly cupgrass in the ½x and 1x acetochlor and isoxaflutole treatments applied D2 was not significantly less at 8 weeks compared to that in the untreated control. In addition, there were no significant differences in emergence between any of the herbicide treatments. Treatments provided good to excellent control at 85 to 99%.

All treatments applied on D1 and D2 demonstrated excellent crop safety, except for significant injury with 1x isoxaflutole applied D2. Corn yields were significantly higher from all treatments applied D2 compared to D1, except the untreated control. Corn yields between the treatments applied D2 were not significantly different from the untreated control. Corn yields ranged from 18 to 90 bu/A with D1 treatments, and from 132 to 155 bu/A with D2 treatments.

EFFICACY AND CROP SAFETY OF POSTEMERGENCE APPLICATIONS OF NICOSULFURON PLUS RIMSULFURON AND MESOTRIONE PLUS S-METOLACHLOR MIXTURES IN CORN, Mick F. Holm, Donald D. Ganske, Susan K. Rick and David W. Saunders, Development Representatives and Product Development Manager, DuPont Ag & Nutrition, Johnston, IA 50131.

Field studies were conducted in corn to determine the effect of tank mixes of Steadfast (nicosulfuron + rimsulfuron) and Camix (S-metolachlor + mesotrione) or Lumax (S-metolachlor + mesotrione + atrazine) on crop safety and efficacy on several grass and broadleaf weed species. Tank mix applications were made utilizing a non-ionic surfactant or non-ionic surfactant plus AMS or 28% nitrogen. Results from weed free trials show no significant crop response across treatments on corn up to 5 inch in height regardless of the additives utilized. In additional trials when applications were made at two different corn heights, crop response ratings were similar to weed free trials and did not vary between application timings. The addition of Camix or Lumax to Steadfast gave excellent control to a broad spectrum of broadleaf grass weed species when applied at labeled weed heights.

UNDERSTANDING THE MECHANISMS OF MANGANESE FERTILIZER ANTAGONISM OF GLYPHOSATE EFFICACY. Mark L. Bernards, Kurt D. Thelen, Donald Penner, Rajendra B. Muthukumaran, and John L. McCracken, Graduate Research Assistant, Assistant Professor, Professor, Postdoctoral Research Assistant, and Professor, Michigan State University, East Lansing, MI 48824.

Glyphosate-resistant soybeans are planted on approximately 80% of the soybean acreage in the United States. On soils where micronutrient deficiencies are common, dealers and producers favor tank-mixing glyphosate with a foliar micronutrient fertilizer. Both growers and researchers have reported antagonism of glyphosate efficacy by some Mn fertilizers (Bailey et al, 2002). The antagonism is dependant upon the fertilizer formulation. Fertilizers with strong chelating agents, such as EDTA, are less likely to antagonize glyphosate efficacy. In greenhouse trials, Mn fertilizer applied up to 3 days before glyphosate reduced control of velvetleaf. However, this phenomenon was specific to velvetleaf. Adding adjuvants such as AMS, EDTA, or citric acid to the tank-mix ameliorates the antagonism, but does not necessarily restore efficacy to the level achieved by a 'glyphosate plus AMS' treatment.

Based on the above results and previous work explaining the hard water antagonism of glyphosate (Thelen et al, 1995), our hypothesis was that Mn interfered with glyphosate absorption because it forms a complex with glyphosate in tank-mixtures.

Growth chamber bioassays were conducted to measure absorption and translocation of ^{14}C-labeled glyphosate in solution with four Mn fertilizers: Mn-ethylaminoacetate (Mn-EAA), Mn-EDTA, Mn-lignin sulfonate (Mn-LS), and $MnSO_4$. When velvetleaf plants reached the 4 leaf stage, the second oldest leaf was wrapped in foil and the plants were sprayed on a track sprayer at 187 L/ha. Glyphosate was applied at 0.28 kg a.e./ha; Mn-EAA, Mn-EDTA, and Mn-LS were tank-mixed with glyphosate at 9.4 L/ha, and $MnSO_4$ was tank-mixed at 7.85 kg/ha. The foil was removed and two 1 μL drops of treatment solution spiked with 1000 Bq/μL were placed on the adaxial surface of the leaf. The treated leaf was rinsed 4, 24, and 48 h after treatment and plants were harvested. Rinsate was analyzed by liquid scintillation. The harvested plants were divided into four parts, then dried, weighed, ground, combusted, and analyzed for ^{14}C-glyphosate by liquid scintillation.

Similar to what was observed in field and greenhouse trials, absorption and translocation of ^{14}C-glyphosate depended upon the fertilizer formulation included in the tank-mixture. Results paralleled what was shown in efficacy trials. Mn-EDTA did not interfere with absorption or translocation of ^{14}C-glyphosate. Both $MnSO_4$ and Mn-LS reduced glyphosate absorption and translocation. Surprisingly, glyphosate in tank-mix solutions with Mn-EAA was absorbed very rapidly. However, very little of the absorbed glyphosate was translocated to the growing point or roots from the treated leaf. Adding AMS increased the amount of glyphosate absorbed for each tank-mixture, and parallels the increased efficacy observed in field and greenhouse trials.

Manganese forms a complex with glyphosate in tank-mixtures. Electron spin resonance spectroscopy (ESR) is a tool used to analyze transition metal behavior in solution. Using ESR we learned that Mn^{2+} binds to glyphosate via the amine N. Each Mn^{2+} complexes with two glyphosate molecules. This is in contrast to calcium which binds to the phosphono- and carboxyl moieties (Thelen et al., 1995), and iron which binds at the phosphono-moiety (McBride and Kung, 1989).

Our results suggest that in fertilizers containting weakly chelated Mn^{2+}, Mn^{2+} forms a 2:1 complex with glyphosate and interferes with glyphosate absorption and/or translocation.

INFLUENCE OF ADJUVANT SYSTEM ON RAINFASTNESS OF GLYPHOSATE. Scott A. Nolte and Bryan G. Young, Graduate Research Assistant and Assistant Professor, Southern Illinois University, Carbondale, IL 62901.

Glyphosate is commonly applied with activator or utility adjuvants to increase glyphosate efficacy or improve spray droplet deposition. Previous research has shown that certain adjuvants do improve herbicide efficacy and rainfastness of previous glyphosate formulations. Research was conducted to determine the influence of selected adjuvants on herbicide efficacy and rainfastness of a recent glyphosate formulation (Roundup WeatherMax).

Glyphosate was applied at 840g ae/ha alone and in combination with ammonium sulfate (AMS), hydroxypropyl guar (HPG), and vegetable oil concentrate (VOC). At 30 minutes after application, rainfall was applied at three volumes (0, 3.2, and 6.4 mm) at a velocity of 12.8 mm/hr with an experimental track sprayer. Under no rainfall, giant foxtail was completely controlled by all treatments. However, control of velvetleaf was the greatest when glyphosate was combined with AMS and no rainfall. In the absence of rainfall, control of common lambsquarters was greatest with no adjuvant while VOC provided less control than all other adjuvants. Compared with the no rainfall treatment, control of all weeds was reduced by up to 60% when simulated rainfall was applied 30 minutes after glyphosate application. When simulated rainfall treatments were applied following herbicide application, little to no difference in adjuvant system was observed for control of giant foxtail, velvetleaf, or common lambsquarters.

FURTHER EVALUATION OF GLYPHOSATE 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.

The proliferation of glyphosate products into the glyphosate resistant crop arena has taken the generic herbicide market to a different level. No matter how many herbicides are introduced the question always comes back to: Will glyphosate product A perform as well a glyphosate product B? Field studies were conducted for three years in five locations across Nebraska to evaluate different brands of glyphosate herbicides. The study was conducted in glyphosate tolerant soybean at Clay Center, Concord, and Lincoln, Nebraska with the exception that glyphosate tolerant corn was used at Clay Center in 2002. The study was conducted in wheat stubble in North Platte and Sidney, Nebraska. In 2001 & 2002 Treatments of 0.42 kg ae/ha and 0.84 kg ae/ha of the following glyphosate products were applied; In 2003 treatments were reduced to 0.31 kg ae/ha and 0.62 kg ae/ha

Herbicides investigated over the three years included Roundup UltraMax, Roundup Ultra, Roundup WeatherMAX, Roundup UltraDry, Touchdown, Clearout 41 Plus, Glyfos Xtra, Cornerstone, Glyphomax, and Glyphomax Plus. Most of the products represent the isopropylamine (IPA) salt of glyphosate however, Touchdown is formulated as the diammonium salt of glyphosate, Roundup UltraDry is formulated as the mono-ammonium salt of glyphosate and Roundup WeatherMAX is formulated as a potassium (K) salt of glyphosate. At North Platte and Sidney locations a product known as Engame was included in the study. Engame is a pure acid formulation of glyphosate. All sites were evaluated for percent control of both grass and broadleaf species at 10-15 and 25-30 DAT..

Over 3 years differences were small and varied slightly across the different trade names in the glyphosate tolerant soybean and corn treatment. Neither Lincoln, Concord, nor Clay Center had any significant differences in control at the 0.42 & 0.84 kg ae/ha or 0.31 kg ae/ha & 0.62 kg ae/ha. Control remained similar across the different rating dates as well for 2001 & 2002 at Sidney, where in wheat stubble, there were once again very few significant differences between products at either rate. At North Platte in 2002 & 2003 and in Sidney in 2003 Engame provided significantly better weed control of kochia and Russian thistle and Sandbur at all rates than any of the K or IPA salt formulations of glyphosate.

As a whole, few differences were seen between different glyphosate brands in this study across the locations especially in row crop situations. However, with a difficult to control species, such as barnyardgrass or in a more demanding climate, such as western Nebraska differences can be easier to find. In these situations the pure acid of glyphosate performed significantly better than the IPA or K formulations of Glyphosate In climates that are less arid climates or with species that are susceptible to glyphosate there seems to be little or no differences between brands. Rate, environmental factors, and cost will most likely play a larger role in the decision process than brand name.

ON FARM SAMPLING OF WEED MANAGEMENT SYSTEMS IN TOMATO PRODUCTION.

David E. Hillger[1], Kevin D. Gibson[1] and Stephen C. Weller[2], Graduate Research Assistant, Assistant Professor of Weed Science and Professor of Weed Science and Molecular Biology, [1]Purdue University, Dept. of Botany and Plant Pathology, West Lafayette IN 47907-2054 and [2]Purdue University, Dept. of Horticulture and Landscape Architecture, West Lafayette IN 47907-2010

Recent concerns over herbicide use, in addition to economic and registration constraints, have limited the number of herbicides available for use in minor crops such as vegetables. The adoption of multi-option integrated weed management systems is vital to the sustainability of vegetable production. However, information on the effects of alternative management systems must be available to producers before they alter their current management systems. The objective of this two year study is to investigate how the management practices of producers affect weed communities and weed control in vegetable production. An advisory board composed of farmers, extension personnel and county agents has been established to identify continuing and emerging problems in weed control, facilitate on-farm data collection, and assess the relative advantages and limitations of different management systems. Twenty producers from Indiana and Michigan representing three tomato production systems (organic, fresh market and processing) supplied detailed field history information and access to their fields for sampling. Weed species diversity and abundance were estimated during summer 2003. Weed seedbank characteristics will be determined by subjecting collected soil samples to a greenhouse germination technique. We are currently conducting multivariate analyses to characterize the relationships between farm management practices and weed communities and control. The results of this study will be made available to growers through outreach activities, extension publications and web-based manuals.

THE UNDERGRADUATE LEARNING FARM – HANDS-ON EXPERIENCES. Christopher L. Schuster and J. Anita Dille, Graduate Research Assistant and Assistant Professor, Agronomy Department, Kansas State University, Manhattan, KS 66506.

Undergraduate education in Agronomy must provide students with specific skills for successful employment. Students need to be technically competent, but must also develop skills in problem-solving, critical thinking, and team work abilities. Agronomy students would greatly benefit from more hands-on experiential learning activities developed to test technical and diagnostic skills. A new facility being made available to undergraduate students at KSU is the Learning Farm, where students can develop these skills through hands-on field site experiences and investigations. The Learning Farm encompasses 80 acres and is located within the Agronomy North Farm, which is three miles northwest of the Agronomy department building. The Learning Farm is divided into a long-range plan of crop and tillage rotations, with a website acting as a resource for all field information www.oznet.ksu.edu/agronomy/academics/undergrad/LearningFarm/welcome.asp. Undergraduate students gain knowledge of the Learning Farm through class field trips, in-class research exercises, and undergraduate research assistantships provided through departmental personnel. One example of a current undergraduate research project at the Learning Farm is understanding site-specific correlations among winter annuals/biennials and soil properties. Initial results indicate a correlation among winter annual emergence and the type of crop residue present during the early fall months. The Learning Farm will provide a venue for integrating skill development throughout the four-year Agronomy curriculum and provide a resource for extension education and developmental training in the future. Continued evaluation of learning and skill development will occur to maximize creativity, innovation, improvement, and coordination involving the Undergraduat
e Learning Farm.

AFTER THE HATCHET FALLS—FINDING A NEW JOB IN WEED SCIENCE. David H. Johnson, Senior Research Associate and Associate Professor, Penn State University, Manheim, PA 17545.

With the continued trends of mergers and downsizing in the ag products industry and a similar trend for downsizing in the public sector, including academia, many people, ranging from newly graduating students to mid- to late-career professionals, are finding job opportunities scarcer and more competition for jobs. Chances are good that we will all be faced with having to find new employment at least once in our careers. In late 2002 I was "downsized", and I hope to convey to others some of my experiences over the four-month period of my job search.

The job search is a process that involves selling—you are selling yourself and your skills and showing how you will benefit the employer. Some items and strategies to consider (they worked for me):

1. Establish and maintain an active network of associates throughout your career. These contacts are both professional and personal and will help you in the job search. Let them know you are looking and what your interests are. Keep it alive, and help someone else when they need it. The vast majority of jobs are found through your network.

2. Utilize career management companies as much as possible. Take full advantage of any services your former employer offers. These companies won't find you a job, but will help you develop a search strategy, define your interests and skills, create a strong resume, and provide information on industries and companies. Many universities also have job and career services available to students.

3. Develop a resume with impact and keep it updated. Use "active" words and show the impact of what you have done. Be brief and to the point, and quantify where possible. Most resumes get less than 1 minute of attention, so you must sell yourself quickly and show how you stand out from other candidates. Include key words that match job descriptions, since many resumes are initially pre-screened by computer before being seen by a hiring manager.

4. Develop informational interview opportunities. These are not job interviews, but an opportunity for you to learn about an industry or company, discuss your job search strategy, and develop potential contacts. The other person also gets the opportunity to learn about you, and may be able to pass on information to another who might have an opening. Develop your 1-minute "advertisement".

5. Prepare thoroughly for your interviews. An interview is your chance to sell yourself. You must convince them that you are the best candidate for the organization. Research an employer as much as possible, including talking to acquaintances who currently or formerly worked there. If possible, find out the names and job titles of the people you will interview with. Go to an interview with questions (you are learning about them as much as they are learning about you), and be prepared to answer questions about yourself. Follow up an interview with thank you letters and reinforce your interest (if that is still the case) in the position. Use this opportunity to sell yourself again.

6. While waiting to hear decisions from a potential employer, pretend that opportunity doesn't exist and keep up the active search and implementing your strategy.

7. After landing the position, maintain and expand your network, keep your resume up to date, and help others in their search as they have helped you in yours.

8. Be patient, persistent, and network, network, network.

2003 North Central Weed Science Proceedings 58:24.

A COMPARISON OF WEED CONTROL PROGRAMS IN GLYPHOSATE RESISTANT SOYBEAN. Terry J. Schulz and Karen A. Renner, Department of Crop and Soil Science, Michigan State University, East Lansing, MI.

The most expensive inputs today in soybean production are seed cost followed by herbicides. This research compared weed control programs in glyphosate resistant and conventional solid-seeded soybean. Soybeans were planted at 448,000 seeds per hectare. Preemergence herbicides were applied immediately after planting. The conventional post-emergence treatments were chosen after scouting the plots when weeds were 3-6 cm in height. Glyphosate was applied to weeds 15-20 cm in height, 7 days after application of the conventional post herbicides. Weed control was evaluated on 24 July, 28 days after emergence applications of glyphosate. Soybeans were harvested October 13 and the net return calculated for each weed control system. Herbicide prices from in season purchase were used in calculating the cost of each treatment. Seed costs were based on dealer prices for purchasing certified, patented, glyphosate resistant seed or purchasing conventional seed or planting saved, conventional, commercially cleaned seed.

Common lambsquarters control was greater than 94% for all herbicide treatments in glyphosate resistant and conventional weed control programs. Annual grass control was less than 90% in conventional treatments of flufenacet + metribuzin PRE followed by a POST treatment of thifensulfuron methyl + lactofen, and sulfentrazone + chlorimuron ethyl PRE followed by a POST application of acifluorfen. Common ragweed control was less than 90% with a treatment of dimethenamid–p PRE followed by thifensulfuron methyl + fomesafen POST, and imazethapyr PRE followed by acifluorfen POST. Metolachlor + metribuzin preemergence followed by cloransulam methyl postemergence provided the best full season weed control. There was no difference in soybean yield among weed control programs in glyphosate resistant or conventional soybeans. Therefore the greatest net return was from the weed control program with the lowest cost of seed + herbicide(s). All of the weed control programs in glyphosate resistant soybeans, with the exception of the glyphosate only treatment (no preemergence herbicide), were more expensive than the conventional weed control programs due to the cost of the seed. The weed control programs in glyphosate resistant soybeans cost a farmer considerably more (24 to 47%) than the average cost of a weed control program in conventional soybeans planted with farmer saved, commercially cleaned seed. A conventional weed control program can also be a considerable savings to a grower when using commercial varieties of non-Roundup Ready soybean seed (11 to 38%) compared to certified, patented, glyphosate resistant seed.

CONTROL OF WHITE COCKLE (Lychnis alba Mill.) WITH FALL AND SPRING HERBICIDE APPLICATIONS. Gary E. Powell and Karen A. Renner, Department of Crop and Soil Science, Michigan State University, East Lansing.

White cockle is generally characterized as a biennial or short-lived perennial weed that reproduces by seed. In Michigan it is often a problem in long term forage, or former forage fields that have been planted to minimum tillage crops. Field experiments were established at two sites to evaluate fall and spring applications of glyphosate, 2,4-D ester, sulfentrazone + chlorimuron, flumioxazin, imazethapyr + glyphosate, and tribenuron-methyl applied alone and as tank mixtures on white cockle. Fall-applied glyphosate at 0.84 kg ae/ha, or any herbicide tank-mixed with glyphosate, resulted in 95% or greater control at the Grass Lake location. Control with spring-applied glyphosate was increased by the addition of flumioxazin, imazethapyr, or tribenuron-methyl; or by sulfentrazone + chlorimuron without glyphosate. At the East Lansing location all fall-and spring-applied treatments that included glyphosate, and the sulfentrazone + chlorimuron treatment, controlled white cockle. Applications of 2,4-D ester at 0.53 kg ai/ha were ineffective when applied either in the fall or spring at both locations.

SUSCEPTIBILITY OF NATURALIZED SERICEA LESPEDEZA IN THE KANSAS FLINT HILLS TO INFECTION BY THE ROOT-KNOT NEMATODE, *MELOIDOGYNE INCOGNITA*. Shannon L. Jordan, Undergraduate Research Assistant, Department of Agronomy, Timothy C. Todd, Instructor of Nematology, Department of Plant Pathology and Walter H. Fick, Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66502.

Sericea lespedeza is a noxious weed in Kansas. It was planted and grown in Kansas from the 1930's to the 1950's for soil stabilization and erosion control. It was also inadvertently planted during the mid 1980's in CRP land. Sericea lespedeza is an aggressive legume that competes with native range plants and is unpalatable to cattle.

Currently, the herbicides triclopyr, metsulfuron, dicamba, and some combinations are recommended for control of sericea lespedeza. Grazing with goats has been suggested as a method of control due to the woody nature of this plant when mature. Currently this is the only method of biological control for sericea lespedeza. However, the root-knot nematode genus *Meloidogyne* is a natural enemy of sericea lespedeza, which can do extensive damage to the plant by suppressing root growth and lowering forage production. Work on breeding lines of sericea lespedeza resistant to the root-knot nematodes for forage appears to have been done from the 1950's to the 1970's. Much of the sericea lespedeza was planted prior to the 1950's and genetic variation in naturalized sericea lespedeza stands in Kansas has been observed. It is a possibility that a portion of the population of sericea lespedeza in Kansas may be susceptible to the root-knot nematode, *M. incognita*. While other species of *Meloidogyne* have also been found to infect sericea lespedeza, *Meloidogyne incognita* is currently found in Kansas. The root-knot nematode could be a source for a method of biological control.

This study was a two-part experiment involving a greenhouse trial and a field trial. Sericea lespedeza seed from a local source was grown in sterile soil in the greenhouse. It was inoculated with *M. incognita* and grown for 6 weeks. After 6 weeks, the roots were incubated and the nematodes were recovered and counted. The results from the greenhouse study showed the plants were susceptible to the nematode and above ground biomass was reduced by 29% compared to the control. In the spring of 2003, a field trial was conducted with a naturalized population of sericea lespedeza in Pottawatomie County, KS. Two methods of application were used. In the first treatment, the nematodes were applied to two furrows down the center of the plot. Nematodes were applied using a hand sprayer over the entire plot in the second treatment. These plots were harvested in the fall of 2003. The roots were incubated and the nematodes counted.

In the greenhouse trial, sericea lespedeza was susceptible to *M. incognita*. Field results suggest sericea lespedeza may be susceptible under natural conditions as well. The results from this study are encouraging for future trials using the root-knot nematodes as a possible biological control method or in combination with other control methods as a treatment regimen. However, care must be taken when considering root-knot nematodes in relation to the location of the study as they can infect some crops.

INVESTIGATING THE INTERACTION BETWEEN ATRAZINE AND MESOTRIONE. Josie A. Hugie, Dean E. Riechers, and Patrick J. Tranel, Graduate Research Assistant, Assistant Professor, and Associate Professor, Department of Crop Sciences, University of Illinois, Urbana, IL, 61801.

Mesotrione is a potent inhibitor of the 4-hydroxyphenylpyruvate dioxygenase (HPPD) enzyme in plants. The HPPD enzyme is involved in conversion of tyrosine to plastoquinone (an essential cofactor for phytoene desaturase) and alpha-tocopherol; thus inhibition of HPPD leads to photobleaching in sensitive plants through the inhibition of carotenoid biosynthesis. Mesotrione is used in corn for both pre- and postemergence broadleaf weed control. Previous field studies have shown that combining mesotrione with a photosystem II-inhibiting herbicide, such as atrazine, results in enhanced weed control, possibly through a synergistic interaction between the two herbicides. Growth response curves (commonly used to determine interactive relationships between herbicides) were used in our experiments to investigate the interaction between atrazine and mesotrione applied postemergence. Greenhouse studies were conducted in which single herbicide treatments were applied to triazine-sensitive and triazine-resistant (site of action based) waterhemp (*Amaranthus rudis*). Rates of atrazine ranged from 5.6 g ai/ha to 1122 g ai/ha, and rates of mesotrione ranged from 3.3 g ai/ha to 210 g ai/ha. Percent visual injury was recorded throughout the initial 10 days after treatment, and plants were harvested two weeks after treatment for dry weight measurement and generation of growth response curves. Triazine-resistant waterhemp was injured more than triazine-sensitive waterhemp by mesotrione alone, indicating a possible negative cross-resistance to mesotrione. Application of 561 g ai/ha of atrazine combined with 105 g ai/ha of mesotrione to the triazine-sensitive biotype showed more atrazine-like injury symptomatology (contact burn on older leaves), while in the triazine-resistant biotype the predominant injury symptomatology was more indicative of mesotrione (bleaching of newer leaves). GR_{50} values will be generated from growth response curves from the single herbicide treatments and will be used to determine the correct rates to use for joint treatments of atrazine plus mesotrione. A final growth response curve will then be generated from the dry weights of plants treated with mesotrione plus atrazine to graphically demonstrate the interaction between atrazine and mesotrione for postemergence activity on triazine-sensitive and triazine-resistant waterhemp.

RESISTANCE TO ALS INHIBITORS IN SELECTED COMMON RAGWEED POPULATIONS FROM THE MIDWEST. Danman Zheng, William L. Patzoldt, and Patrick J. Tranel, Graduate Research Assistant, Graduate Research Assistant, and Associate Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Several common ragweed populations previously were reported resistant to the methyl ester of cloransulam, an acetolactate synthase (ALS)-inhibiting herbicide. Subsequent research revealed that resistance to cloransulam in at least one population was conferred by an altered herbicide target site; specifically, by a leucine-for-tryptophan substitution at amino acid position 574 of ALS. Research was conducted to determine if this substitution was correlated with resistance to ALS inhibitors in other common ragweed populations.

Sixteen plants from each of 22 common ragweed populations originating from eight Midwestern states were treated with either cloransulam at 17.5 g ai ha^{-1} plus 1% (by vol) COC and 2.5% (by vol) UAN, or imazamox at 44 g ae ha^{-1} plus 1% COC and 2.5% UAN. Dry weights were obtained 20 days after treatment and compared to eight plants from each population treated with 1% COC and 2.5% UAN only. A plant was considered resistant if its dry weight was at least 30% relative to the non-herbicide-treated controls. Each of the herbicide-treated plants also was assayed to determine whether its *ALS* alleles contained leucine or tryptophan codons at position 574 (designated L574 and W574 alleles, respectively) by using allele-specific primers in PCR reactions.

Based on herbicide efficacy data, the 22 common ragweed populations were classified into three groups: sensitive to both herbicides (six populations), resistant to both herbicides (ten populations), and resistant to imazamox but not to cloransulam (six populations). Of the 352 plants analyzed for cloransulam resistance, 21% (75) were resistant and all but two of these resistant plants contained at least one L574 allele. Of the 352 plants analyzed for imazamox resistance, 44% (156) were resistant; however, nearly half (74) of these resistant plants did not contain an L574 allele. Whether or not the L574 allele corresponded with imazamox resistance was population dependent. There were five populations in which the presence of L574 alleles corresponded with imazamox resistance on a plant-by-plant basis, and 11 populations in which one or more imazamox-resistant plants did not contain an L574 allele. Plants with imazamox resistance but without L574 alleles are being investigated further to determine if they contain ALS substitutions previously shown to confer imidazolinone-specific resistance. Summed across both herbicides, 1% (5) of the plants scored as sensitive unexpectedly contained an L574 allele. A conclusion from this study is that an L574 allele is the predominant basis for cloransulam resistance in common ragweed; however, other mechanisms of resistance to ALS inhibitors, particularly to imazamox (and likely other imidazolinones), are also frequent in common ragweed.

MOLECULAR CHARACTERIZATION OF THE GENE ENCODING PROTOPORPHYRINOGEN OXIDASE FROM WATERHEMP. William L. Patzoldt, Aaron G. Hager, and Patrick J. Tranel, Graduate Research Assistant, Assistant Professor, and Associate Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Recently, a waterhemp biotype with resistance to protoporphyrinogen oxidase (PPO)-inhibiting herbicides was identified in Illinois. Since waterhemp is the first plant species to have evolved resistance to PPO inhibitors under field settings, little is known regarding the mechanism of resistance. As part of our investigation, we are comparing PPO inhibitor-resistant and -susceptible waterhemp biotypes at the molecular level to determine if the mechanism of resistance is mediated by alterations in the nucleotide sequence or over-expression of the gene(s) encoding the herbicide target-site.

Plants have two PPO isozymes, located in either plastids or mitochondria and encoded by *PPX-I* or *PPX-II*, respectively, both of which are inhibited by herbicides. Since *PPX-1* and *PPX-II* have not yet been sequenced in waterhemp, we began our research by obtaining the full-length sequence of *PPX-I*. Using known sequences of *PPX-I* from spinach, tobacco, and mouse-ear cress, primers were created to sequence a fragment of *PPX-I* from waterhemp. This fragment was used to create gene-specific primers to obtain the full-length sequence by 5' and 3' RACE (Rapid Amplification of cDNA Ends). Initial sequencing results from the fragment of *PPX-I* from waterhemp indicated that it was most similar in nucleotide sequence to the spinach gene. Interestingly, the PPO enzyme encoded by *PPX-II* from spinach has been identified in two isoforms due to the existence of dual initiation codons: one isoform is targeted to the mitochondria, while the other is targeted to the plastid. Given this scenario, a single alteration could potentially confer PPO inhibitor resistance to plastidic and mitochondrial PPO enzymes.

PHYSIOLOGICAL BASIS OF GLYPHOSATE RESISTANCE IN RIGID RYEGRASS (*LOLIUM RIGIDUM*). Marulak Simarmata and Donald Penner, Michigan State University, Department of Crop and Soil Science, East Lansing, MI 48824.

Rigid ryegrass collected in California in 1998 has been selected for 7 generations to separate the susceptible (S) and resistant (R) biotypes. Past research has not elucidated the basis for glyphosate resistance in rigid ryegrass. Foliar absorption, distribution in the plant, and intercellular movement of glyphosate into chloroplast did not explain the observed resistance. Inheritance of glyphosate resistance appears to be multigenic. The objective of this study was to determine the role of metabolism and 5-enolpyruvylshikimate-3- phosphate synthase (EPSPS) in glyphosate sensitive (S) and glyphosate resistant (R) biotypes. Metabolism of ^{14}C-glyphosate was not evident in either the susceptible or glyphosate resistance rigid ryegrass. EPSPS activity from the (R) biotype was inhibited 0 and 25% at 0.5 and 5 mM glyphosate; and the EPSPS activity from the (S) biotype was inhibited 38 and 51% at 0.5 and 5 mM glyphosate, respectively. The data indicate that the difference in sensitivity of EPSPS to glyphosate is a major contributor to the observed glyphosate resistance in the (R) biotype of rigid ryegrass.

SURVEY OF COMMON WATERHEMP RESISTANCE TO PROTOX- AND ALS-INHIBITING HERBICIDES. Jeanne S. Falk*, Douglas E. Shoup, Kassim Al-Khatib, and Dallas E. Peterson, Graduate Research Assistant, Graduate Research Assistant, Professor, and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

A population of common waterhemp in northeast Kansas was confirmed resistant to protoporphyrinogen oxidase (protox)- inhibiting herbicides in 2001. In 2002, seed was collected in a 16 km radius from the confirmed resistant population to determine the extent of protox resistance in common waterhemp populations throughout this area. Waterhemp seed from multiple plants was collected from 28 fields, including 20 soybean, five corn, two wheat stubble and one sorghum field. A composite sample of waterhemp seed from each field was germinated and grown under greenhouse conditions for herbicide screening. At seven to 13 cm in height, eight common waterhemp seedlings were treated with 210 g ai ha^{-1} acifluorfen, 70 g ae ha^{-1} imazethapyr, or 1060 g ai ha^{-1} glyphosate. Plants were evaluated for visual injury at one, two, and three weeks after treatment (WAT). Common waterhemp plants from 10 of the 28 sites exhibited resistance to acifluorfen. These sites were randomly scattered throughout the sampling area. Protox resistant waterhemp was initially injured by acifluorfen, however injured plants generally recovered within 2 WAT. These plants were stunted, but produced several branches. All sites exhibited resistance to imazethapyr. In addition, all of the sites tested were susceptible to glyphosate. These findings show that protox- resistance is present in 10 of the 28 fields sampled and ALS- resistance is present in most of the waterhemp populations throughout sampling area. Therefore, herbicides with these modes of action may not be viable tools for common waterhemp control in northeast Kansas.

IN VITRO SELECTION OF DNA APTAMERS THAT BIND AMITROLE Zhu Jie and Balazs Siminszky, Department of Agronomy, University of Kentucky, Plant Science Building Room 433, Lexington, KY 40546-0312

We have applied SELEX (Systematic Evolution of Ligands by Exponential enrichment), a combinatorial method for isolating biopolymers that selectively bind to a target. Our objective was to identify single-stranded DNA sequences able to bind amitrole, a widely used herbicide that is difficult to isolate from environmental samples. SELEX selection was performed using an amitrole-derivatized affinity chromatography column. Single-stranded DNA aptamers were eluted from the affinity column with a free amitrole-containing buffer. Amitrole-binding ssDNA molecules were PCR amplified, and the dsDNA was used as a template for asymmetric PCR to generate ssDNA. The cycle then was repeated. As expected, aptamer yield increased with each cycle of selection indicating an increase in the binding-affinity of the selected ssDNA molecules to amitrole. The final product of SELEX, a ssDNA aptamer characterized by high amitrole affinity, could constitute the basis for the development of highly selective solid-phase extraction sorbents, sensitive detectors and other ligand binding-based applications, providing new tools for monitoring herbicides in the environment.

HOST RANGE OF *MYROTHECIUM VERRUCARIA* ISOLATED FROM SICKLEPOD. Kathleen I. Anderson and Steven G. Hallett, Research Assistant and Assistant Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

A frequent problem with pathogens developed as bioherbicides for cropping systems is a high level of host specificity and their concomitant inability to deliver effective control of complex weed communities. *Myrothecium verrucaria* (Hyphomycetes), isolated from sicklepod, was investigated for bioherbicide potential against a range of economically important weed species from agronomic and horticultural systems. *M. verrucaria* was grown on PDA for 14-21 d, and then plates were flooded with 30 ml sterile distilled water and colonies agitated with a sterile cotton swab. The resulting suspension was filtered through three layers of cheesecloth and adjusted to a conidial concentration of 2 x 10^7 conidia/ml in 0.05% (v/v) Silwet L-77 and applied as a foliar spray. Symptoms typically appeared within 1-3 days after application, and were primarily characterized as wilting and necrosis. A number of weed species, including common lambsquarters, hemp sesbania, waterhemp and most other dicots tested were highly susceptible, whereas some species, including yellow nutsedge, large crabgrass, green foxtail and most other monocots tested were resistant. These findings suggest that the sicklepod isolate of *M. verrucaria* deserves further investigation for broad spectrum weed control.

PROTOPORPHYRINOGEN OXIDASE (PROTOX)-RESISTANT COMMON WATERHEMP RESPONSE TO HERBICIDES AT DIFFERENT GROWTH STAGES. Douglas E. Shoup*, Jeanne S. Falk, Kassim Al-Khatib, and Dallas E. Peterson, Graduate Research Assistant, Graduate Research Assistant, Professor, and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

A biotype of common waterhemp in Kansas with resistance to protox-inhibiting herbicides has a high level of resistance to acifluorfen, lactofen, fomesafen, and sulfentrazone when applied as a postemergence treatment. However, field experiments with preemergence treatments of sulfentrazone or flumioxazin resulted in greater than 85% control of the resistant common waterhemp biotype. Two experiments were conducted at the site where the resistant biotype was confirmed to determine common waterhemp response to herbicides at different stages of growth. The first experiment was conducted in 2002 and 2003. Protox-inhibiting herbicides acifluorfen, lactofen, fomesafen, sulfentrazone, flumioxazin, oxyfluorfen, and azafenidin were applied as preemergence and postemergence treatments. A second experiment was conducted in 2003 to evaluate common waterhemp response to herbicides applied at three different growth stages: two leaf, four to six leaf, and eight to ten leaf. Herbicide treatments were acifluorfen, fomesafen, bentazon, acifluorfen + bentazon, fomesafen + bentazon, bentazon + paraquat, and 2,4-DB. In 2002, all protox-inhibiting herbicides applied preemergence gave greater than 80% common waterhemp control, whereas postemergence herbicide control was less than 55% for all herbicides except flumioxazin, where control was 78%. In 2003, only preemergence treatments of lactofen, fomesafen, and oxyfluorfen gave greater than 80% common waterhemp control, whereas oxyfluorfen was the only postemergence herbicide that gave less than 55% control. For the second experiment, common waterhemp control at the two-leaf growth stage was greater than 80% for all herbicides except bentazon and 2,4-DB where control was 46 and 73%, respectively. At the four- to six-leaf growth stage, control was greater than 80% for all herbicide treatments except acifluorfen at the low rate, bentazon, and 2,4-DB, where control was 74, 77, and 48%, respectively. At the eight- to ten-leaf growth stage, only acifluorfen + bentazon, fomesafen + bentazon, and paraquat + bentazon gave greater than 80% common waterhemp control. Control with all other herbicide at the eight- to ten-leaf growth stage was between 50 and 68%.

ISOLATION AND CHARACTERIZATION OF TOBACCO CYTOCHROME P450 cDNAS INVOLVED IN HERBICIDE METABOLISM. Lily B. Gavilano and Balazs Siminszky, Post-Doctoral Research Associate and Assistant Professor, University of Kentucky, Agronomy Dept., Lexington, KY 40546.

Cytochrome P450 monooxygenases catalyze the metabolism of a large array of herbicides. While overexpression of P450 genes isolated from corn, arabidopsis and soybean have been shown to confer resistance to herbicides, very few P450 genes involved in herbicide metabolism have been isolated from tobacco. In addition to improving our understanding about the molecular biology of P450-mediated herbicide metabolism, the isolation and characterization of herbicide metabolizing P450s and their use for engineering herbicide-resistant tobacco may ultimately provide more weed management options in direct-seeded tobacco. The objective of this project is to isolate and characterize P450 genes that are involved in herbicide metabolism. We have identified 43 unique P450 sequences from a large tobacco EST database and used a modified 5' RACE PCR strategy for isolating the full-length version of 15 randomly selected P450 cDNAs. The full-length cDNAs were subcloned into a plant expression vector and the resulting construct was introduced into tobacco via Agrobacterium-mediated plant transformation. P450 transcript accumulation was measured by Northern blot analysis and seed were harvested from individuals exhibiting the highest level of mRNA expression. Experiments are underway to determine the degree of herbicide tolerance of each transgenic line against selected herbicides.

Nematode Community as Affected by Glyphosate-Resistant Cropping System. Konanani B. Liphadzi, Kassim Al-Khatib*, Timothy Todd, J. Anita Dille, Kansas State University, Manhattan, and Curtis Bensch, Oklahoma Panhandle Research and Extension Center, Goodwell

Glyphosate use has significantly increased since the introduction of glyphosate-resistant cropping system. Long-term experiments were established in 2001 at Manhattan and Hays, KS to study the effect of glyphosate-resistant cropping system on nematode community under conventional and no-tillage systems. Herbicide treatments were conventional preemergence herbicide, glyphosate applied when weeds were 10 cm tall and when weeds were 20 cm tall. Glyphosate-resistant soybean or corn were grown in rotation. Soil samples were collected in April/May and October/November of each year. Nematodes were extracted from a 100 g soil sub-sample, identified to family or genus level, and assigned to trophic groups. Total nematode densities were higher at Manhattan than in Hays. Overall nematode community was not altered by glyphosate application when compared to conventional herbicide at both locations. Conventional tillage system had higher nematode densities than no-tillage system. At Manhattan, total nematode density in conventional tillage was at least 50% more than in no-tillage. The overall impact of glyphosate-resistant cropping system on nematode community did not differ from conventional herbicide.

ANALYSIS OF SOIL MICROBIAL COMMUNITIES ASSOCIATED WITH WEEDS USING DENATURING GRADIENT GEL ELECTROPHORESIS OF PCR-AMPLIFIED RIBOSOMAL RNA GENES (PCR-DGGE). Kathleen I. Anderson and Steven G. Hallett, Research Assistant and Assistant Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Interactions between weeds and soilborne microbes may have numerous important agronomic impacts, and may be amenable to manipulations in integrated weed management systems. For example, soil microbial communities may play an important role in the decline of weed seedbanks by accelerating weed seed decay or by inhibiting the growth of emerging weed seedlings. Although there is significant anecdotal evidence for these impacts, they have received very little attention. This is partly due to the fact that soilbone microbes are difficult to study in detail, and effective techniques have become available only recently.

Here, we report a preliminary experiment investigating the potential for using denaturing gradient gel electrophoresis of PCR-amplified small subunit RNA genes (PCR-DGGE) to distinguish between the rhizosphere communities of different weeds growing in the same soil. Shattercane, velvetleaf, field bindweed, jimsonweed and eastern black nightshade were grown in the same field soil for 14-21 days in pots in the greenhouse. Roots were then excavated from pots and shaken roughly to dislodge loosely attached soil. DNA was then extracted from the soil that remained attached to the roots (rhizosphere soil) using a bead-beating protocol. Small regions of small-subunit ribosomal RNA genes were amplified by PCR and the PCR products were separated by DGGE.

DGGE profiles demonstrate that the rhizosphere microbial communities associated with replicate plants of the same species are very similar, but that the rhizosphere microbial commuities associated with different species grown in the same soil are considerably different. The experiment demonstrates the feasibility of utilizing PCR-DGGE for the analysis of soil microbial communities associated with weeds. Additionally, this experiment demonstrates the ability of plant roots to exert a species-specific influence upon soil microbial communities. As we develop a more detailed understanding of this phenomenon, we hope the we will be able to use it to design strategies to create soil microbial communities that are suppressive to weed species.

Functional Diversity and Biomass Carbon of Soil Microbes under Glyphosate-Resistant Cropping System. Konanani B. Liphadzi*, Kassim Al-Khatib, Charles Rice, J. Anita Dille, Kansas State University, Manhattan, and Curtis Bensch, Oklahoma Panhandle Research and Extension Center, Goodwell

The introduction of glyphosate-resistant crops had led to a significant increase in glyphosate use. A long-term field experiment was established in 2001 at Manhattan, KS to study the effect of glyphosate on soil microbial biomass carbon (SMBC) and functional diversity under conventional and no-tillage environment(s). Herbicide treatments were conventional preemergence herbicide, glyphosate applied when weeds were 10 cm tall and when weeds were 20 cm tall. Glyphosate-resistant soybean or corn were grown in rotation. Soil samples were collected monthly during the crop growing period. SMBC was determined using fumigation-incubation technique. BIOLOG procedure was used to determine functional diversity of the soil microbes. Both SMBC and functional diversity were not altered by glyphosate application when compared to conventional herbicide. SMBC did not differ between tillage treatments. The study clearly showed that microbial response to glyphosate-resistant cropping system was similar to that of conventional herbicide.

VOLUNTEER FLAX AND CANOLA CONTROL IN FIELD PEA. John B. Christianson[1], Kirk A. Howatt[2], Brian M. Jenks[1], Gregory J. Endres[3], Denise M. Markle[1], Gary P. Willoughby[1], North Dakota State University, Minot, ND[1], Fargo, ND[2], Carrington, ND[3].

The wide variety of crops grown in North Dakota can result in the problem of multiple volunteer crop species in a field, which compete with the crop and may require multiple herbicide applications to obtain satisfactory control. Experiments were conducted at three locations in North Dakota to find effective strategies to control volunteer flax (*Linum usitatissimum*) and volunteer canola (*brassica napus*) in field pea (*Pisum sativum*). Herbicide treatments included an untreated control, three rates of metribuzin (210, 315, and 420 g ai/ha) applied preemergence (PRE), and three rates of metribuzin (70, 140, and 210 g ai/ha) and one rate of bentazon, acifuorfen, and MCPA applied postemergence (POST). Crop response and volunteer control was evaluated 14 days after POST application. Field pea was harvested for yield at physiological maturity at all three locations. Location by treatment interaction prevented combing any data. MCPA and acifluorfen generally caused the greatest injury to field pea (10 to 19%). Metribuzin, especially the two lower rates at each application, was safe to field pea, causing less than 7% injury. Acifluorfen at 210 g ai/ha POST provided the most consistent volunteer flax control at 76%. MCPA and bentazon appeared to have no effect on flax. All herbicide treatments provided at least 58% control of canola. There was wide variability in yield among the locations. Metribuzin at 315 g ai/ha PRE generally controlled volunteer crops, resulting in the greatest field pea yield. Field pea treated with acifluorfen, controlled volunteer flax, resulting in the second highest yield average in spite of injury caused to field pea immediately after application. Overall, metribuzin at 315 g ai/ha PRE, 140 g ai/ha POST, 210 g ai/ha POST, or acifluorfen provided the best volunteer flax and canola control, resulting in the greatest yields.

CONTROL OF WINTER AND SPRING ANNUAL WEEDS IN SOYBEANS WITH FALL AND EARLY PREPLANT APPLICATIONS OF CHLORIMURON ETHYL + SULFENTRAZONE + TRIBENURON METHYL VS CHLORIMURON ETHYL + TRIBENURON METHYL. Marsha J. Martin, Helen A. Flanigan, Donald D. Ganske, Kevin L. Hahn, Leslie Lloyd, and David W. Saunders. Development Representatives and Product Development Manager, DuPont Ag and Nutrition, Johnston, IA 50131.

In small plot field trials, tank mixes of Classic + Express (chlorimuron ethyl + tribenuron methyl) were compared to tank mixes of Canopy XL + Express (chlorimuron ethyl + sulfentrazone + tribenuron methyl) in fall or early pre-plant application timings. Testing was conducted in fall 2000/ spring 2001 and fall 2002/ spring 2003 in Iowa, Indiana, Illinois, Missouri, Ohio, Pennsylvania, and Wisconsin.

For burndown of all weed species rated, Classic + Express tank mixes performed similarly to comparable rates of Canopy XL + Express from both fall and spring applications. Except for eastern black nightshade, waterhemp species, and annual bluegrass, residual performance of Classic + Express was similar to Canopy XL + Express. Higher rates of Canopy XL + Express applied in the fall or early preplant gave suppression of these three weeds, whereas equivalent rates of Classic + Express gave no suppression.

PREPLANT HERBICIDES FOR CONTROL OF HERBICIDE-RESISTANT HORSEWEED IN SOYBEAN. Geoffrey D. Trainer*, Mark M. Loux, S. Kent Harrison, and Anthony F. Dobbels, Graduate Research Assistant, Associate Professors, and Research Associate, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210.

In recent years, producers in Ohio have with increasing frequency been unable to control horseweed with glyphosate or ALS-inhibiting herbicides. Field studies were conducted in glyphosate-tolerant soybeans in the fall and spring of 2001/2002 at one location, and in 2002/2003 at three sites throughout Ohio. The horseweed population at the 2001/2002 site was characterized as ALS-resistant in greenhouse research, and populations at two of the 2002/2003 sites were characterized as glyphosate-resistant. The objectives of these studies were to determine: a) the effectiveness of soybean herbicides applied in the fall and spring for residual control of horseweed, and b) the effectiveness of preplant soybean herbicides for the control of emerged horseweed.

In the residual study, various herbicides were applied with 2,4-D ester in early November or early April, when horseweed seedlings were less than 10 cm in diameter and prior to stem elongation. When applied in the fall of 2001, imazaquin, sulfentrazone, metribuzin, flumioxazin, and flumetsulam were the most effective treatments in late May of 2002, but they only controlled 73 to 80% of the ALS-resistant horseweed. Chlorimuron plus sulfentrazone, flumioxazin, flumetsulam, cloransulam, and sulfentrazone controlled 80 to 100% of the non-resistant horseweed in late May of 2003 when applied the previous fall. Early-spring applications of these herbicides were more effective for residual control of horseweed, controlling 83 to 98% of the horseweed in late May of 2002, and 87 to 100% in 2003. Horseweed population densities ranged from 13 to 78 plants/m^2 for fall treatments and 0 to 44 plants/m^2 for spring treatments in 2002. In 2003, population densities ranged from 0 to 24 plants/m^2 for fall treatments and 0 to 4 plants/m^2 for spring treatments.

In a second study, herbicides were applied in early May when the horseweed plants were 7 to 15 cm tall. Combinations of glyphosate, chlorimuron, and sulfentrazone or glyphosate, 2,4-D, chlorimuron, and sulfentrazone were the only treatments that controlled 100% of the horseweed at all sites 28 DAT. Treatments that controlled at least 90% of the horseweed at all sites included glyphosate plus 2,4-D applied alone or in combination with metribuzin or flumioxazin, and a combination of metribuzin, glufosinate, and 2,4-D. Glyphosate controlled 90 to 97% of the ALS-resistant and non-resistant horseweed but not more than 68% of the glyphosate-resistant horseweed. However, combinations of several other herbicides with glyphosate generally resulted in greater than 90% control of glyphosate-resistant horseweed.

PREPLANT HERBICIDES FOR CONTROL OF DANDELION IN CORN AND SOYBEANS. Mark M. Loux and Anthony F. Dobbels, Associate Professor and Research Associate, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210.

Field studies were conducted at two locations in Ohio in 2003 to determine: 1) the effectiveness of preplant corn and soybean herbicides for control of dandelion; and 2) the effect of spring application timing on control of dandelion with glyphosate and 2,4-D. For the first objective, corn and soybean herbicides were applied in late April in northwest (NW) and west central (WC) Ohio, during a period of below-average temperatures. No-tillage corn and glyphosate-tolerant soybeans were planted approximately one week after herbicide application. Corn received a postemergence treatment of dicamba plus diflufenzopyr, and soybeans received a postemergence treatment of glyphosate. Mesotrione plus atrazine was the most effective preplant corn herbicide treatment across both locations, controlling 97 and 87% of the dandelion 28 DAT in WC and NW Ohio, respectively. The addition of 2,4-D ester to this treatment improved late-season control of dandelion, and resulted in greater reduction in dandelion population density in NW Ohio. Mesotrione treatments reduced population density by at least 95% in WC Ohio and by 77 to 88% in NW Ohio, compared to untreated plots. Treatments controlling 83 to 93% of the dandelion 28 DAT in WC Ohio included isoxaflutole plus atrazine plus 2,4-D, atrazine plus glyphosate, and atrazine plus glyphosate plus 2,4-D. These treatments reduced dandelion population density by 68 to 92%. These same treatments controlled only 73% of the dandelion 28 DAT in NW Ohio, but they reduced dandelion population density by up to 75%.

Soybean herbicide treatments at WC Ohio included glyphosate applied alone and in combination with one or more of the following: 2,4-D ester, flumioxazin, carfentrazone, and chlorimuron plus sulfentrazone. Combinations of paraquat with 2,4-D, metribuzin, and chlorimuron plus sulfentrazone were also included. All treatments controlled 88 to 100% of the dandelion 28 DAT, with the exception of glyphosate plus carfentrazone plus 2,4-D and paraquat plus metribuzin plus 2,4-D. At soybean harvest, dandelion control ranged from 93 to 100%, and the reduction in dandelion population density ranged from 92 to 100%.

For the second objective, glyphosate and 2,4-D ester were applied at 0.8 and 1.1 kg ae/ha, respectively, in the fall and at 10-day intervals in the spring between April 1 and May 20. All of these treatments were followed with a postemergence application of dicamba plus diflufenzopyr in corn in NW Ohio, or glyphosate in soybeans in WC Ohio. The fall treatments averaged 90% dandelion control at the mid-May evaluation, and glyphosate and glyphosate plus 2,4-D treatments were generally more effective than 2,4-D. Dandelion control with the spring treatments averaged 63 and 85% in NW and WC Ohio, respectively, in late-June, but both herbicide and timing affected control. In NW Ohio, control averaged across herbicides ranged from 93 to 94% for applications on May 10 or 20, but did not exceed 65% for earlier applications. When averaged over timing in NW Ohio, 2,4-D applied in the spring provided 44% control, glyphosate, 59% control, and glyphosate plus 2,4-D, 85% control of dandelion. In WC Ohio, control averaged across herbicides ranged from 86 to 94% for all timings except April 1, when it averaged 64%. When averaged over timing in WC Ohio, 2,4-D applied in the spring provided 73% control, glyphosate, 88% control, and glyphosate plus 2,4-D, 94% control of dandelion. Similar differences among locations, timing, and herbicide were observed for late-season measurements of dandelion population density.

RESPONSE OF HORSEWEED TO FOLIAR APPLIED HERBICIDES. James R. Martin, William W. Witt, and Charles H. Slack, Extension Professor, Professor, and Research Specialist, Department of Agronomy, University of Kentucky, Princeton, KY 42445.

Four different studies were conducted in 2003 to evaluate various foliar- applied herbicide programs for managing horseweed (*Conyza canadensis*) in stubble or clipped fields. The Trigg county study had a glyphosate- tolerant population and dealt mainly with applications made during the fall and following spring; whereas, the two studies in Princeton and the one in Lexington had glyphosate-susceptible populations and involved foliar sprays made in spring or mid summer.

Very little horseweed was observed when the fall treatments were made at the Trigg County site in December; consequently, any herbicides applied at this time had no direct affect on postemergence control of horseweed control. However, a fall spray of a non-residual postemergence herbicide, such as glyphosate, provided favorable environment for spring emergence of horseweed by eliminating competition from cool-season weeds such as little barley and mouseear chickweed. Following up with a spring burndown treatment of glyphosate in these plots did not control horseweed and therefore confirmed the glyphosate tolerance that observed the previous season. However, including 2,4-D ester with the spring application of glyphosate did control horseweed. The fall spray of chlorimuron + sulfentrazone premix in combination with tribenuron plus 2,4-D controlled annual broadleaf weeds, including horseweed, up to April 23. The fact that horseweed escapes in this treatment became more evident by May 8 indicated the soil-residual activity of this treatment had dissipated. The spring burndown application of paraquat in combination with either 2,4-D or the premix of chlorimuron plus sulfentrazone provided complete control of glyphosate tolerant horseweed by May 8.

The first study in Princeton compared glyphosate, 2,4-D ester, dicamba, and cloransulam applied to 12-, 14-, and 20- cm tall horseweed on April 26, May 3, and May 10, respectively. Glyphosate provided at least 98% horseweed control for all three sizes of plants. Control with 2,4-D ranged from a low of 33% when applied at 0.46 lb ae/A without crop oil concentrate to 20-cm tall horseweed. However, a high of 98% control occurred when 2.4-D was applied at 0.93 lb ae/A with crop oil concentrate to 12-cm tall horseweed. Applying 2,4-D at 0.93 lb ae/A with crop oil concentrate to 20-cm tall plants resulted in only 56% horseweed control. Horseweed control with dicamba ranged from a low of 27% when applied at a rate of 0.125 lb ai/A to 20-cm tall horseweed plants compared with a high of 88% when applied at a rate of 0.25 lb ai/A to 12-cm tall plants. Applying dicamba at 0.25 lb ai/A to 20-cm tall plants resulted in only 43% horseweed control. Horseweed control with cloransulam did not exceed 53% regardless of size of plants.

The second study at Princeton evaluated the effect of clipping on horseweed control with foliar-applied herbicides. Treatments were applied May 30 to non-clipped plants 33 cm tall and to plants that were clipped to a 20-cm height. Glyphosate applied alone or in combination with 2,4-D, cloransulam, or the premix of chlorimuron plus sulfentrazone provided at least 96% horseweed control regardless whether plants were clipped or not clipped. However, treatments involving paraquat provided only 63 to 67 % horseweed control of plants that were not clipped compared with 98% control where plants were clipped.

The Lexington study evaluated six glyphosate formulations including ClearOut 41 Plus, Honcho, Roundup UltraMax, Roundup WeatherMax, Touchdown IQ, and Touchdown KPMG applied at a rate of 0.75 lb ae/A. Other treatments included paraquat applied alone or in combination with the premix of cloransulam plus sulfentrazone. Treatments were applied July 2 to horseweed clipped to a height of 31 cm. Horseweed control with the different glyphosate formulations at 2 weeks after application was variable and ranged from 80 to 98%. However, by 3 weeks after application, control was at least 95% for all formulations. Control at 3 weeks after application with paraquat alone at 0.75 lb ai/A was 72% compared with 88% for paraquat at1 lb ai/A. Including the premix of chlorimuron at 0.029 lb ai/A plus sulfentrazone at 0.15 lb ai/A with paraquat at 0.75 lb ai/A provided 90% horseweed control at 3 weeks after application.

DANDELION CONTROL WITH SPRING APPLIED TREATMENTS IN NO-TILL SOYBEAN.
Reece A. Dewell, William G. Johnson, and J. Earl Creech, Postdoctoral Research Assistant, Assistant Professor, and Graduate Research Assistant, Purdue University, West Lafayette, IN 47907.

The combination of no-till production practices and low-residual postemergence herbicide programs has led to a resurgence of several perennial weed concerns. Dandelion is one such concern in Indiana, especially in the northeastern portion of the state. A field study was conducted near Huntington, IN, about 10 to 15 miles SSE of the Northeast Purdue Agricultural Center (NEPAC), to evaluate various herbicide combinations for spring dandelion control in soybean. Preplant treatments were applied on April 26 and soybeans drilled on May 31 by the cooperating farmer. A late postemergence blanket treatment of glyphosate (Roundup Weathermax) was applied by the cooperating farmer on July 3 to the entire study area. Visual dandelion control ratings were collected 19 DAT – pre, 37 DAT – pre, 73 DAT – pre / 5 DAT lpost, 86 DAT – pre / 18 DAT lpost, and 188 DAT – pre / 120 DAT lpost. At the early rating, the addition of 2,4-D to all glyphosate combinations reduced dandelion control. In contrast, the addition of 2,4-D (ethylhexyl ester) to paraquat combinations resulted in increased dandelion control. By the 37 DAT – pre rating, these 2,4-D interactions were only observed with glyphosate + flumioxazin (94% vs. 58%) and glyphosate + carfentrazone (87% vs. 74%). Glyphosate at 1.16 lb/A, glyphosate + 2,4-D (0.77 + 0.94 lb/A), and paraquat + chlorimuron ethyl&sulfentrazone +2,4-D were the only treatments still providing >85% control 73 DAT – pre. An attempted rating on August 7 (35 DAT – lpost) indicated that the late postemergence application (0.5625 lb/A glyphosate) made by the cooperating farmer on July 3, temporarily provided near complete dandelion control. A post harvest rating on October 31 showed that all chlorimuron ethyl&sulfentrazone (with or without 2,4-D) treatments were still providing >85% control. At this post harvest rating, glyphosate alone (both rates), glyphosate + 2,4-D (0.77 + 0.94 lb/A), and glyphosate + flumioxazin were providing >85% control also. (Dept. Botany and Plant Pathology, Purdue University, West Lafayette, IN).

EFFECT OF GLYPHOSATE RATE AND APPLICATION TIMING ON COMMON COCKLEBUR, VELVETLEAF, AND COMMON WATERHEMP SEED PRODUCTION, VIABILITY, GERMINATION, AND DORMANCY. Brent M. Swart, Micheal D.K. Owen, and Allen D. Knapp, Graduate Student, Professor of Agronomy, and Associate Professor of Agronomy, Iowa State University, Department of Agronomy, Ames, IA 50011-1010

Glyphosate is the primary herbicide for weed control in soybean production systems in the U.S.. Glyphosate programs are very attractive to soybean producers due to the wide use of glyphosate resistant soybeans, the ease and flexibility of application, and the wide weed control spectrum. Soybean producers, looking to lower input costs, may reduce herbicide rates. Unfavorable environmental conditions may force untimely glyphosate applications. Field and laboratory experiments were conducted in Ames, IA in 2002 at two different field locations to determine the influence of post-emergence application timings and rates of glyphosate on seed production, viability, germination, and dormancy of common cocklebur, velvetleaf, and common waterhemp in soybeans. Viability of common cocklebur seed was significantly lower than untreated controls in one location but not the other while common waterhemp viability was also significanlty lowered. Germination and dormancy of common cocklebur and common waterhemp seeds were not significantly different than untreated controls at any location. Bur production was considerably affected by glyphosate treatment as nearly all common cocklebur plants treated with any rate of glyphosate died. Common waterhemp seed production was reduced from controls for all timings except the early-postemergence timing. Velvetleaf germination and dormancy were significanly affected by glyphosate rates while viability was not. Velvetleaf seed production responded differently to application timings with greatest reductions when glyphosate was applied during flowering. Overall, reduced seed production was the most consistant affect of glyphosate application timings and rates.

CONTROL OF DANDELION WITH FALL-APPLIED HERBICIDES. Anthony F. Dobbels and Mark M. Loux, Research Associate and Associate Professor, The Ohio State University, Columbus, OH 43210.

An increasing number of grain crop producers in Ohio have reported problems with dandelion over the past several years. The population density of dandelion has been sufficient to reduce corn and soybean yields in some fields, and control of dandelion with herbicides applied in the spring has been inconsistent. Field studies were conducted at two locations in Ohio to determine the effectiveness of herbicide treatments applied in the fall prior to corn or soybeans for control of dandelion. Herbicide treatments were applied in mid-November of 2002, and no-tillage corn or glyphosate-tolerant soybeans planted in late April or early May of 2003. Corn received a preplant application of atrazine plus s-metolachlor and a postemergence application of dicamba plus diflufenzopyr. Soybeans received a postemergence application of glyphosate. Treatments were visually evaluated for dandelion control at the time of crop planting, postemergence herbicide application, and crop harvest. The population density of dandelion was also measured at the time of crop harvest.

When evaluated at the time of corn planting, the most effective fall treatment was rimsulfuron plus thifensulfuron plus 2,4-D, which controlled 89% of the dandelion. Simazine plus 2,4-D and glyphosate plus 2,4-D controlled 58 and 53% of the dandelion. Control ranged from 67 to 80% at the time of corn harvest, and herbicide treatments reduced the population density of dandelion 60 to 76% compared to the untreated plots. In the soybean studies, treatments containing glyphosate, glyphosate plus 2,4-D, or chlorimuron plus sulfentrazone plus 2,4-D controlled 87 to 100% of the dandelion at the time of soybean planting. Control was slightly reduced for some of these treatments by the time of soybean harvest, but they resulted in an 87 to 100% reduction in dandelion population density at one location, and a 78 to 92% reduction at the second location. Fall application of 2,4-D alone controlled 67 to 80% of the dandelion at the time of planting, and reduced the dandelion population density 19 to 75%. Increasing the 2,4-D rate from 0.6 to 1.1 kg/ha increased control and resulted in a lower dandelion population density. Fall-applied soybean herbicides were generally more effective for dandelion control at the west-central Ohio location, compared to the northwest Ohio location, possibly due to warmer conditions around the time of application at the former. In both corn and soybean studies, where fall herbicides were omitted and activity on dandelion was due solely to postemergence herbicides, control of dandelion did not exceed 30%.

INDEPENDENT RESPONSES OF SOYBEAN EARLY GROWTH TO STRESSES CAUSED BY SOYBEAN CYST NEMATODE AND POST-EMERGENCE HERBICIDE APPLICATIONS. Ramon G. Leon and Micheal D. K. Owen, Graduate Research Assistant and Professor, Department of Agronomy, Iowa State University, Ames, IA 50011.

Soybean cyst nematode (SCN; *Heterodera glycines* Ichinoche) causes great yield losses in soybeans across the Midwest United States. Although it is not well understood what influences SCN infection, several studies and farmers reports suggested that stressed soybean plants are more susceptible to SCN infection. Also, it has been proposed that post-emergence herbicides (POST) are among the stress causing agents responsible for increased soybean susceptibility to SCN. However, researchers also showed that some POST herbicides, such as acifluorfen, besides causing transient stress to the soybean, can induce defense mechanisms that might minimize SCN infection. Therefore, it is not known if SCN and POST effects interact to increase or diminish soybean growth. The objective of this study was to determine the existence of interactive responses of soybean growth to stresses caused by SCN and POST applications. In order to precisely isolate the effect of those stresses and reduce the variability due to environmental conditions, the experiments were conducted in controlled greenhouse conditions. Soybean plants were grown in pots with soil infested with either low (10 eggs cm^{-3} soil) or high (100 eggs cm^{-3} soil) SCN egg population density. Soybeans were sprayed at V3 growth stage with acifluorfen at 421 g a.i. ha^{-1}, imazethapyr at 70 g a.i. ha^{-1}, and glyphosate at 840 g a.e. ha^{-1}. Also, a non-treated control was included in the experiment. Visual injury was determined at different times after POST application, and the plants were harvest 65 days after planting and growth parameters were measured. The experiment had four replications and was conducted three times. No interactions between SCN and POST were observed, and only SCN main effect explained reductions in soybean growth. Plants grown in soil with high SCN had less leaf area and lower biomass than plants grown in soil with low SCN. However, the reduction of those soybean parameters was only around 10%. Although some visual injury was observed in soybeans sprayed with acifluorfen and imazethapyr, none of the POST treatments differed from the non-treated control regarding soybean growth parameters. In general, acifluorfen caused 20% visual injury in the first 14 days after application (DAA), but when the plants were harvested, the results from the injury were negligible. In the case of imazethapyr, the highest injury observed was 2% at 7-14 DAA. Glyphosate did not cause any visual injury. The results of the study showed that POST did not affected SCN susceptibility, and the reductions in soybean growth were due to SCN and not to POST. Therefore, the observations made by farmers and from previous field studies suggesting a possible interaction between SCN and POST are not supported. Instead, it is possible that other factors present in the field are likely important to increase soybean susceptibility to SCN.

WEED CONTROL IN NO-TILLAGE ZUCCHINI SQUASH PRODUCTION. S. Alan Walters, Mark F. Rundle, Scott A. Nolte, Joseph L. Matthews, and Bryan G. Young, Assistant Professor, Graduate Research Assistant, Researchers, and Associate Professor, Southern Illinois University, Carbondale, IL 62901.

Weed management in no-tillage vegetable production systems is a major problem, as tillage is often used in conventional production systems to reduce weed populations that preemergence herbicides fail to control. Various species of *Amaranthus*, including redroot pigweed, are problematic in no-tillage squash production in Illinois. A field study was conducted in 2002 and 2003 to evaluate various herbicides and herbicide combinations with or without a winter rye grass cover crop in no-tillage zucchini squash production. All herbicides were applied preemergence one day prior to transplant of squash plants.

In 2002, control of crabgrass at 56 days after herbicide treatment (DAT) was influenced by herbicide treatment but not cover crop. Crabgrass control was similar from all treatments that included ethafluralin & clomazone but significantly less from halosulfuron. There was an interaction between herbicide treatment and cover crop for redroot pigweed control at 56 DAT. Tank mixing halosulfuron or imazamox with ethafluralin & clomazone increased control of redroot pigweed compared with ethafluralin & clomazone alone with a ryegrass cover crop but not in the absence of a cover crop. The presence of a rye grass cover crop did not affect redroot pigweed control from any herbicide treatment except ethafluralin & clomazone plus imazamox. Redroot pigweed control from ethafluralin & clomazone plus imazamox was 22% greater in plots with a cover crop compared to no cover crop. In 2003, there was an interaction between herbicide and cover crop, with the greatest control of crabgrass observed from ethafluralin & clomazone with a rye grass cover crop. Control of redroot pigweed was not affected by herbicide treatment or cover crop in 2003.

TECHNIQUES TO EVALUATE SWEET CORN TOLERANCE TO NICOSULFURON AND MESOTRIONE. Dean S. Volenberg, Tim L. Trower, Chris M. Boerboom, and William F. Tracy, Postdoctoral Research Associate, Research Specialist, Professor, and Professor, Univ. of Wisconsin-Madison, Madison, WI 53706.

Few effective herbicide options exist for Midwest sweet corn producers. Although there are numerous effective herbicide options for field corn, these herbicides may severely injure sweet corn. Nicosulfuron is the only postemergence grass herbicide labeled for use in sweet corn. However, nicosulfuron is only labeled for use on 37 hybrids of processing sweet corn. Another herbicide option for sweet corn producers is mesotrione once it becomes labeled for use in sweet corn. Sweet corn hybrids have tolerance to mesotrione when applied preemergence, whereas certain sweet corn hybrids are injured when mesotrione is applied postemergence. Several field studies have examined sweet corn hybrid tolerance to nicosulfuron and mesotrione and identified tolerant sweet corn hybrids. A limitation of these tolerance studies is that they perpetuate field studies, which are often influenced greatly by environmental conditions and may provide inconsistent results. These studies also fail to provide critical information to sweet corn breeders so they can make selections that have known levels of herbicide tolerance. Therefore, our objectives were to develop techniques which could consistently differentiate tolerant and susceptible sweet corn hybrids to nicosulfuron and mesotrione.

A ragdoll technique was evaluated as a technique to distinguish tolerant and susceptible sweet corn hybrids to nicosulfuron. The hybrids tested were Bonus, GG202, GG214, GH2547, 2038, Merit, and SS Jubilee. Twenty five seeds of each hybrid were soaked in 0, 1, 2, 4, 6, and 8 ppm ai nicosulfuron for 24 h at 25±1 C. After 24 h, the remaining solution was drained from the seeds. Seeds were placed equidistant on two layers of water-saturated #38 germination paper (25.5 x 38.5 cm) and then covered with another sheet of water saturated germination paper. Sheets containing seeds were rolled up and placed in a 25±1 C growth chamber for 5 d. Hypocotyl length was quantified. The hypocotyl lengths were compared against the length of nontreated hypocotyls and Fishers protected LSD was used to separate treatment means. The experiment was repeated three times.

A field study across different environments was conducted to determine if specific mesotrione treatments could consistently distinguish tolerant and susceptible sweet corn hybrids. The hybrids tested were SS Jubilee, Dynamo, GH1861, 610, GH2547, and Bonus. Sweet corn hybrids were treated at the V2 stage with mesotrione at 0.1, 0.2, and 0.3 kg ha-^{1} containing 1% v/v crop oil concentrate (COC) or 1% v/v COC and 2.5% v/v urea-ammonium nitrate (UAN). A visual assessment of percent chlorosis as compared with the nontreated control was taken 4 to 6 d after application. The experiment was repeated three times.

The ragdoll technique consistently distinguished nicosulfuron-tolerant from-susceptible sweet corn hybrids. Bonus and GG214 were the most tolerant, whereas Merit was the most susceptible at all concentrations of nicosulfuron. Nicosulfuron at 1 ppm provided the greatest separation among hypocotyl lengths. The order from most to least tolerant at 1 ppm was Bonus>GG214>GG202>SS Jubilee>2038>2547>Merit.

Mesotrione at 0.3 kg ha-^{1} with adjuvants of COC and UAN was consistent in distinguishing tolerant and susceptible sweet corn hybrids. The addition of UAN at 2.5% v/v to the spray solution increased the severity of mesotrione chlorosis to sweet corn. However, without the addition of UAN to the spray solution, it was more difficult to distinguish tolerant from susceptible hybrids. GH2547, 610, and Bonus had greater mesotrione tolerance than SS Jubilee, GH1861, and Dynamo.

In the future, we propose to develop F_2, S_1, and S_2 populations from these hybrids and study the inheritance of herbicide tolerance using the above techniques. Information on inheritance can then be provided to breeders in the sweet corn industry.

2003 North Central Weed Science Proceedings 58:51.

GIS AS A TOOL FOR WEED MANAGEMENT IN INDIANA MINT. Mary S. Gumz and Stephen C. Weller, Graduate Research Assistant and Professor, Purdue University, Department of Horticulture and Landscape Architecture, West Lafayette, IN 47907.

Peppermint (*Mentha piperita*) and the spearmints (*M. spicata* and *M. cardiaca*) (“mint”) are grown in northern Indiana as essential oil crops and are Indiana’s largest acreage horticultural crop. Mint is considered an “at-risk” crop due to pressure from foreign production and synthetic flavorings and regulatory loss of key herbicides. Due to the limited number of herbicides available, a whole systems approach to weed control is necessary. In addition to effective use of herbicides, mint must be optimally managed in order to produce a strong healthy stand that can outcompete weeds. A GIS -based research approach to mint production was begun in Northern Indiana in 2002 and is ongoing. The goal of this project is to improve mint production efficiency through site-specific techniques with an initial emphasis on weeds and their management. Mint fields were selected to represent a wide range of soil types and within-field variability, including mint stand, weed infestation, and disease. Three-band multispectral aerial images were taken of mint fields at two to three week intervals during both seasons. Field conditions, including mint stand health and weed infestations, were ground referenced using DGPS receivers. Analysis of these images to find predictive spectral responses for various weed infestations and crop conditions is using MultiSpec©. Classification of mint crop vigor and areas of weed infestation, have been achieved with greater than 90% overall accuracy. Classification of some individual weed species, such as Canada thistle has also been achieved. Results indicate that mint’s competitive ability with weeds is determined by mint stand vigor which is influenced significantly by soil type and field moisture status. The health of the mint stand influences the distribution of and type of weed species present. In fields of healthy, vigorous peppermint, weed distribution is patchy and weeds are most prevalent in areas where there is no mint present. In low vigor mint fields, weed infestations occur throughout the field. These results indicate that a systems based approach using GIS technology has potential for use in achieving optimum weed control and production efficiency in mint.

IMPACT OF SITE SPECIFIC WEED MANAGEMENT ON WEED POPULATIONS. Jeffrey W. Vogel, J. Anita Dille Phillip W. Stahlman, Graduate Research Assistant, Assistant Professor, and Professor, Kansas State University, Manhattan, KS 66506.

Integrated and Site Specific Weed Management (ISSWM) provides an opportunity to manage weeds where they are using advanced application technology and knowledge of spatial locations of weed species. A two-pass system for ISSWM is proposed in order to minimize risk of missing weed populations: a variable or low rate preemergence herbicide followed by a map-based postemergence herbicide application. The objective of this study was to assess the outcome of weed populations and crop yield in response to ISSWM program. A field study was conducted at the Department of Agronomy Ashland Bottoms Research Farm, south of Manhattan in 2003. A preemergence herbicide premix of flufenacet and metribuzin (204 g ha^{-1} + 302 g ha^{-1}) was applied in 7.62 m strips (10 rows wide) at 0, 0.33, 0.67, and 1x the recommended rate on June 11. On July 9 weed species were identified, classified into size categories, and counted in 1 m^2 quadrat at the center of each 7.62 x 7.62 m grid superimposed on the field and was assumed to represent the population of that grid cell. Each preemergence strip was split into a site specific treatment using the most economical herbicide rates assigned to each 7.62 x 7.62m grid cell and a random treatment in which a 7.62 x 22.9 m strip randomly received 0, 0.5, 0.75, and 1x the recommended rate. The postemergence herbicide chosen was bentazon, sethoxydim, aciflourfen, and COC (227 g ha^{-1} + 85 g ha^{-1} + 57 g ha^{-1} + 1.2 L ha^{-1}) and applied July 10. Weed counts were taken 3 weeks after treatment and crop yield was obtained using a combine equipped with a yield monitor on October 23. Palmer amaranth, common waterhemp, shattercane, velvetleaf, prickly sida, and yellow foxtail were observed. Frequency distribution of July 9 weed counts with increasing preemergence herbicide rate shifted to lower densities and lots of zero counts. Compared to a uniform postemergence application of the 1x recommended rate, the site specific treatment only required 10% of the area to be treated across all preemergence rates. In total, herbicide use was reduced by 94% in the site specific treatment. In general, yields varied across the field site due to other factors and no real differences were observed by preemergence or postemergence treatments.

EFFECT OF TILLAGE ON COMMON WATERHEMP EMERGENCE AND VERTICAL DISTRIBUTION OF SEED IN THE SOIL. Dawn E. Nordby, Extension Specialist, Weed Science IPM, University of Illinois, Urbana, IL 61801 and Robert G. Hartzler, Professor, Department of Agronomy, Iowa State University, Ames, IA 50011.

Field studies were conducted near Ames, IA in 2001 and 2002 to determine the effects of tillage on the behavior of common waterhemp (*Amaranthus rudis* Sauer) in the soil seedbank. Emergence of common waterhemp was greater in no-till than chisel till. Tillage did not affect the initial time of emergence; however, the time to 50% emergence was longer in no-till than chisel till. Duration of emergence did not differ among tillage systems. Common waterhemp seed was concentrated near the soil surface in no-till, whereas seed in the chisel till were primarily found between 9 and 15 cm. The delayed and increased emergence in no-till contributes to the problems in managing common waterhemp in this system.

FACTORS AFFECTING WEED SEED SURVIVAL IN SOIL SEEDBANKS. James Iannuzzi, Adam S. Davis* and Karen A. Renner, Undergraduate Research Intern, Research Associate and Professor, Michigan State University, East Lansing, MI 48824.

Population models indicate that managing agroecosystems to reduce weed seed survival in soil seedbanks has the potential to decrease weed populations. A series of bioassays was conducted in soil collected from the Long Term Ecological Research site at the Kellogg Biological Station in Hickory Corners, MI. We determined the effect of 1) contrasting agricultural management, 2) burial method, 3) surface sterilization, and 4) mechanical damage to seed coats on the proportion of weed seeds surviving a 28 d incubation in soil at 25 C and 330 kPa matric potential. Weed species included common lambsquarters, field pennycress, giant foxtail, kochia, velvetleaf, and yellow foxtail. Each of the four factors studied significantly ($P < 0.05$) affected weed seed survival. Seed mortality rates of both giant foxtail and velvetleaf were 20 to 40% lower in soils managed with low or no chemical input compared to conventionally managed soils. Burying seeds in mesh bags, a common experimental practice, increased velvetleaf seed mortality due to an increase in fatal germination, but had the opposite effect on giant foxtail seeds. Surface sterilization of the seed coat with 5% bleach for 5 minutes decreased velvetleaf seed survival by 7%, but increased giant foxtail seed survival by 40%. Survival of all six weed species was reduced by mechanical damage to the seed coat, with large declines in velvetleaf and kochia seed survival (77 and 83%, respectively). The wide range of weed seed survival rates in response to altered abiotic and biotic conditions holds promise for the development of agricultural management practices that reduce weed seed survival in soil seedbanks.

THE SPATIAL RELATIONS BETWEEN WEED POPULATIONS AND GROUND BEETLE POPULATIONS IN THE FIRST YEAR OF A TRANSITION TO ORGANIC PRODUCTION. Lindsay Reinhart, John Masiunas, Undergraduate Hughes Fellow and Associate Professor, University of Illinois, Urbana, IL 61801, Jon Lundgren, Graduate Research Assistant, Illinois Natural History Survey, Champaign, IL 61820, and Marty Williams, Research Agronomist, USDA-ARS, Urbana, IL 61801.

The process of shifting from cropping systems that rely on synthetic fertilizers and pesticides to cropping systems following organic practices can be difficult for farmers. It is generally believed that weed populations and the difficulty of control increase as a field moves through transition. Once the field is through the transition process and becomes a stable organic system, it is thought that weed problems decrease. Research is needed to confirm these observations and to understand the underlying processes. The objectives of our research were to determine the distribution of weed and ground beetle populations in a field transitioning to organic; evaluate the impact of transition approach on those populations, and determine if initial ground beetle and weed populations were correlated. The three transition systems were: a low input pasture system with perennial grasses and legumes; a medium intensity agronomic system with cash grains; and a high intensity system with vegetable crops. The dominant weed species differed depending on the transition systems. The high intensity system with tomatoes largely had volunteer wheat due to the wheat straw used as a mulch between the crop rows being contaminated with seed. Common lambsquarters and velvetleaf were the two dominate species in the low and medium intensity systems. The medium intensity system with soybeans had the fewest weeds due to between-row cultivation and the competitiveness of the crop. The weeds were aggregated in the field and herbaceous ground beetle populations were correlated with the weed populations.

WEED COMMUNITY COMPOSITION AFTER SIX YEARS IN GLYPHOSATE-RESISTANT CORN AND SOYBEAN. Mark R. Jeschke and David E. Stoltenberg, Graduate Research Assistant and Professor, University of Wisconsin, Madison, WI 53706.

Research was conducted at the University of Wisconsin Arlington Agricultural Research Station from 1998 through 2003 to determine the effects of crop rotation, primary tillage system, and glyphosate use intensity on weed community composition. Six weed management treatments were compared in continuous corn and a corn-soybean annual rotation, and in three different primary tillage systems: moldboard plow, chisel plow, and no-tillage. Weed management treatments were based on six levels of glyphosate use intensity: glyphosate applied post-emergence, glyphosate applied post-emergence and late post-emergence, glyphosate applied post-emergence followed by inter-row cultivation (in corn only), glyphosate applied post-emergence rotated annually with a non-glyphosate herbicide program, a soil-residual herbicide applied pre-emergence followed by glyphosate applied post-emergence, and a non-glyphosate program. Plots were maintained in the same location for the duration of the experiment. Weed species richness (number of species) and plant density of each species were measured several times each growing season.

Weed species richness and diversity at the time of post-emergence herbicide application varied among crop rotation, tillage, and weed management treatments. Crop rotation was a significant source of variation of weed species diversity in 1998 only, and was not a significant source of variation for weed species richness. Tillage system was a significant source of variation of species richness in 1998, 2001, and 2003, and a significant source of variation of species diversity in 1998, 1999, and 2001. Weed management treatment was a significant source of variation for both parameters in each year. Weed community composition in glyphosate-based treatments changed little over time, whereas weed community composition changed rapidly, in as few as 3 yr, in non-glyphosate treatments. Species richness and the number of abundant weed species were typically greater in treatments that included glyphosate as the sole herbicide chemistry compared to non-glyphosate treatments, which were typically dominated by one or two weed species. Common lambsquarters, velvetleaf, pigweed species, eastern black nightshade, and giant foxtail were the most abundant weed species over time in glyphosate-based treatments. In contrast, giant ragweed and shattercane became the dominant weed species over time in non-glyphosate treatments. These two species were associated with substantial crop yield losses, particularly in crop rotation and tillage treatments where weed density was high. Glyphosate-based weed management treatments were typically associated with greater weed species richness, diversity, and community stability over time compared to non-glyphosate treatments, suggesting that the risk of rapid change in weed community composition was similar to or less than that of non-glyphosate treatments.

EARLY-SEASON MORPHOLOGY OF GIANT RAGWEED AND WOOLLY CUPGRASS AS AFFECTED BY CROP-MEDIATED CHANGES IN LIGHT QUALITY. Greta G. Gramig and David E. Stoltenberg, Graduate Research Assistant and Professor, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

Process-based descriptions of competition between weed and crop plants require knowledge of the mechanisms underlying alterations in plant morphology that are key determinants of resource acquisition among competitors. Plants use an array of physiological mechanisms to sense changes in resource availability and to alter production and distribution of biomass so that investments maximize returns, i.e. competitive ability. Numerous studies conducted in controlled environments have documented altered biomass allocation patterns in response to changes in light quality. Exposure to decreased red/far-red (R/FR) ratios, which are characteristic of plant canopies where red wavelengths are preferentially absorbed, has been associated with changes in root to shoot ratio, vertical leaf area distribution, stem length, specific leaf area, and branching pattern. Previous results suggest that plants sense subtle changes in R/FR ratios that occur before mutual shading; it has been hypothesized that this may be a critical mechanism for early neighbor detection and avoidance. Few studies have investigated the effects of decreased R/FR ratios on competitive interactions among plants in the field, where light intensities far exceed those in controlled environments, and where other important environmental variables fluctuate both spatially and temporally. Our objective was to determine if crop-mediated changes in light quality are associated with early changes in weed morphology in the field. Preliminary experiments were conducted to investigate methodological approaches, with the results primarily intended for planning of subsequent experiments.

Four field experiments were conducted in 2003 at the University of Wisconsin-Arlington Agricultural Research Station. The design of each experiment was a randomized complete block with three replications. The experiments were giant ragweed in corn, giant ragweed in soybean, woolly cupgrass in corn, and woolly cupgrass in soybean. Standard agronomic practices were used for seed bed preparation, fertilization, and crop planting. Weed seeds were planted by hand 1 d after crop planting. Each plot consisted of a 6.10-m long row of target weed plants equidistant between two rows of neighbor crop plants spaced 0.76-m apart. Light quality treatments were imposed by 1) removal of neighbor crop plants at emergence, 2) removal of neighbors when shading of weeds commenced, and 3) no removal of neighbor plants. A spectroradiometer with a 25-degree field of view was used to measure the spectral composition of horizontally propagated radiation from 325 to 1,075 nm at the apex of target weed plants. Spectral irradiances of 645 and 735 nm were used to calculate R/FR ratios. Target weed plants were measured before mutual shading to determine shoot height and volume, mainstem internode number and length, leaf area, branch or tiller number, and biomass of leaves, branches, and mainstems. Root biomass was measured for woolly cupgrass only. Analysis of variance and specific paired comparisons were used to assess the effect of treatments on plant morphological attributes including total shoot dry biomass, specific mainstem length (SSL), leaf area ratio (LAR), leaf to shoot ratio (LSR), specific leaf area (SLA), leaf mass ratio (LMR), shoot height, branch or tiller number, average mainstem internode length, mainstem internode number, and root to shoot ratio (RSR). Analysis of variance was also used to determine treatment effects on R/FR ratios.

Prior to mutual shading, R/FR ratios were consistently lower for target weed plants with adjacent neighboring crop plants, except for giant ragweed in corn. Woolly cupgrass LSR, LMR, and RSR were greater without corn neighbors than with corn neighbors. In soybean, woolly cupgrass RSR was greater without crop neighbors than with neighbors. In corn, giant ragweed SSL, LAR, and SLA were lower and biomass was greater without crop neighbors. For giant ragweed in soybean LAR was lower and number of branches was greater without neighbors. These results suggest that early season shifts in R/FR ratios were associated with changes in weed morphology, but that the response was species-specific.

2003 North Central Weed Science Society Proceedings 58:60.

MORPHOLOGY OF WATERHEMP X SMOOTH PIGWEED HYBRIDS. Federico Trucco, Patrick J. Tranel, A. Lane Rayburn, and Kenneth R. Robertson, Graduate Research Assistant, Associate Professor, Associate Professor, and Professor, Department of Crop Sciences and State Natural History Survey, University of Illinois, Urbana, IL 61801.

Many populations of *Amaranthus* species have been reported resistant to one or multiple herbicides. Hybridization among these species is thought to contribute to their evolutionary adaptability and may be a route for resistance transfer. Previous work suggests high potential for hybridization between waterhemp (*A. rudis* and *A. tuberculatus*) and smooth pigweed. However, the apparent morphological similarity between waterhemp and its hybrid progeny makes field surveys for hybrids difficult to conduct. The objective of this study was to identify reliable morphological characters that could be used to distinguish waterhemp from waterhemp x smooth pigweed hybrids. To do this, hybrids were obtained from field crosses and their identities corroborated with molecular and cytogenetic tools. Hybrids and individuals of the parental species were grown in the greenhouse and evaluated for more than 25 morphological characters. Significant differences (alpha = 0.05) between hybrids and either or both of the two parents were obtained for nine characters or algebraic relations. In summary, hybrid leaf length-to-width ratio was intermediate to that of parents. Hybrids had longer pistillate bracts and tepals and a greater tepal-length-to-urticle-length ratio than waterhemp. Staminate bracts were longest in hybrids, and staminate bract-length-to-tepal-length ratio in hybrids was greater than in waterhemp. In general, hybrid female inflorescences exhibited globular patterns at branching points and an overall feathery appearance. However, the qualitative characters evaluated were not as reliable. Although many quantitative characters show statistical significance when individuals of known identity are used, it might be difficult to use any one of these characters to positively identify hybrids. Rather, a combination of these characters could be used to identify putative hybrids in field surveys and molecular or cytogenetic tools used to confirm/contradict expected identities.

GROWTH AND DEVELOPMENT OF TRUMPETCREEPER (*CAMPSIS RADICANS*) DURING FIRST YEAR OF ESTABLISHMENT IN TWO TILLAGE REGIMES. Michael W. Marshall and J.D. Green, Research Specialist and Extension Specialist, University of Kentucky, Lexington, KY 40546.

The adoption of conservation or no-tillage production has resulted in dramatic and beneficial changes in soil physical properties. In Kentucky, the soils and topography are well suited to these limited tillage production systems because they allow an effective means to reducing soil erosion and plant nutrient losses by water while growing a crop on sloping land. However, one the major drawbacks to no-tillage production is the increase of populations of difficult to control perennial dicots, such as trumpetcreeper. Seed production is not commonly observed in plants found growing in agronomic fields; however, undisturbed established (> 5 years old) plants produce seed pods and they are typically found growing adjacent to agronomic fields. These seed are potentially transferred and/or spread to nearby agronomic fields by wildlife and other dispersal mechanisms. The objective of this study was to quantify, non-destructively, the growth and development of seedling trumpetcreeper transplants introduced into two different tillage regimes. Trumpetcreeper seeds were collected from established plants in and around fencerows on roadsides in Nelson County in Central Kentucky. Field experiments were conducted in Central Kentucky at Lexington and in Western Kentucky near Princeton. In 2001 and 2002, tillage blocks were tilled in the spring using a tandem disk set to depth of 7.6 cm. No-tillage blocks were left undisturbed. Seedling trumpetcreeper, at the 2- to 3-leaf stage, were transplanted to the field (Late May to Early June) to establish a uniform population. Transplants were initiated from seed planted in peat tablets in the greenhouse six weeks before transplanting to the field. Experimental design consisted of a randomized complete block with 3 replications of each tillage regime (2 years and 2 locations). Data collected were vine length, number of compound leaves per vine, and number of plantlets initiated per vine at the following intervals: 1, 2, 3, and 4 months after transplant (MAT). The term plantlet is defined as a stem axil that produces an adventitious root where it touches the ground. Data were analyzed using random coefficient analysis where quadratic models for each measure were fitted against time for each pot and tested at the $P = 0.05$ level to determine significant differences between tillage (T) and no-tillage (NT) as follows. Average slope and curvature parameters for T and NT were tested separately for significance using the sign rank test. When curvature or slope parameters were not significant for both tillages, they were dropped from the model. Next, comparisons were made using ANOVA for the remaining parameters to determine if significant differences occurred between tillages. If none were detected for slope or curvature parameters, a composite T + NT model was fitted. Population data 1 year after establishment was analyzed across tillage using ANOVA and means separated using pair-wise comparisons. At Lexington, models were fitted for vine length, compound leaves per vine, and plantlets per vine and pooled across T and NT because no significant differences were detected. At Princeton, models fitted for vine growth and compound leaves per vine were significantly different across tillage regime. However, plantlets per vine models were not significantly different across tillage regime. Trumpetcreeper population, 1 year after transplant, were significantly higher in the NT environments in 2002 and not significantly different between tillages in 2003 across both locations (but higher than initial population). In conclusion, tillage regime did have an impact on rate vine length production and number of compound leaves per vine at Princeton, but did not have an effect on rate of vine length production, compound leaves per vine at Lexington. Plantlets initiated per vine did not differ at both Princeton and Lexington. Number of plantlets produced per vine increased dramatically throughout the growing season and the significant number of new plants arising the following season indicated that this form of vegetative reproduction is very important for its propagation in agronomic fields.

EVALUATING COMMON DANDELION POPULATION DIVERSITY USING RAPD MARKERS.
Aaron S. Franssen, David S. Douches, and James J. Kells, Graduate Research Assistant, Professor and Professor. Michigan State University, East Lansing, MI 48824.

The increased adoption of no-tillage cropping practices has contributed to the widespread occurrence of common dandelion (*Taraxacum officinale*) in Michigan and the Midwest. Inconsistent control of common dandelion with common postemergence herbicides has been observed and has lead to the hypothesis that distinct biotypes of common dandelion exist and respond differently to herbicides. To evaluate common dandelion genetic diversity, mature seeds were collected from selected field populations in Michigan and several other states. Individual plants were selected from field populations to represent the population. Common dandelion plants were established in the greenhouse and transplanted to a field nursery.

Genomic DNA was extracted from the youngest leaf tissue and screened with 10 base pair RAPD primers. Polymorphic fragments were scored as either present (+) or absent (-). Only those fragments which were repeatable and intensely amplified were scored. Genetic distances between biotypes were determined using Nei's distance formula. Dendograms were created using the unweighted pair group method with arithmatic averages (UPGMA) cluster analysis. Genetic distance calculations and dendograms were made using NTSYSpc version 2.11L software. The amount of diversity observed from the RAPD analysis indicated that common dandelion is highly variable and the genetic distance and geographical distance between biotypes did not appear to be highly correlated.

USING MOLECULAR MARKERS TO EXAMINE RELATIOSHIP AMONG WEEDY SOLANUM SPECIES. Altanbadralt Sharkhuu, Peter B. Goldsbrough, and Stephen C. Weller, Graduate Research Assistant and Professors, Purdue University, Department of Horticulture and Landscape Architecture, West Lafayette, IN 47907.

Molecular marker research is being conducted to relate biological, ecological and genetic factors to growth pattern of a variety of Solanaceous species common in the Midwestern United States. Seeds of more than two hundred samples belonging to six nightshade (*Solanum americanum, S. nigrum, S. ptycanthum, S. carolinense, S. sarrachoides* and *S. dulcamara*) and three groundcherry (*Physalis angulata, P. heterophyl* and *P. subglabrata*) weed species were collected throughout Ohio, Indiana, Illinois and Michigan. The experiment used RAPD molecular marker analysis to evaluate the degree of genetic variation occurring within and between of these species. Multiple independent DNA samples were obtained from individual greenhouse grown plants. Eight primers were used in the RAPD analysis based on consistency of results in preliminary experiments. A total of 412 RAPD markers for 114 individuals belonging to the sampled species were run. Seventy of these individuals were scored (presence or absence of strong reproducible bands) by the Numerical Taxonomy and Multivariate Analysis System program. Based on the scored genetic polymorphisms, a genetic tree was formed. Bootstrap analysis was used to assess the significance of the genetic relationships observed in the tree. The genetic relationships indicate: black nightshade and American nightshade species are more genetically similar to each other than to other nightshade species; eastern black nightshade separated into 2 closely related groups as did hairy nightshade; horsenettle separated into 3 distinct groups; and bitter nightshade and groundcherry groupings were distinct from each other and from all nightshade species. The results show that RAPD analysis is useful for distinguishing genetic relationships within a particular nightshade species and allows a determination of genetic variation between nightshade species.

VARIATION IN EASTERN BLACK NIGHTSHADE ACCESSIONS. John B. Masiunas, Associate Professor, University of Illinois, Urbana, IL 61801.

The *Solanum nigrum* complex (*Solanum* Sect. *Solanum*) is a cosmopolitan group of approximately 30 species. Many of the species in the complex are troublesome weeds in horticultural crops, especially solanaceous vegetables such as tomatoes and peppers. In eastern North America the dominant weedy nightshade species is eastern black nightshade, *Solanum ptycanthum* Dun. ex DC. Eastern black nightshade is an annual becoming a short lived perennial in the southern portion of its range (southern IL, southern IN, KY, boot heel of MO). The plants are up to 1m erect, often freely branching. The underside of the seedling leaf is purple. Flowers are yellow-colored in clusters of up to six flowers. Mature berries are globose, shiny, purplish-black, detaching when mature, and containing 6 to 15 hard sclerotic granules. The presence of sclerotic granules are one of the key identification characteristics for mature eastern black nightshade. The plants are prolific producers of berries (over 5,000 berries on some plants) and each can contain up to 100 seed. Several related species including American black nightshade (*S. americanum* Auct.) and black nightshade (*S.* nigrum) are similar in appearance to eastern nightshade. American black nightshade is common in Florida, the Gulf coast, and California. Black nightshade is an introduced species found primarily in California. The black nightshade complex has been difficult to classify into species because of extensive morphologic variation. In eastern black nightshade we found variation in life cycle, plant size, growth habit, flower size, berry color at maturity, growth rate, and berry production. Eastern black nightshade competes with crops for resources (nitrogen, light, water), contaminates crops, increases harvest difficulty, and serves as a secondary host for crop pests. Our research found that nightshade and tomato competed for light. The critical period for competition is during flowering and fruit development. As few as 1 plant/m of row can reduce tomato yield and delay maturity. The greatest yield reductions occur when nightshade overtop the tomatoes. Staking tomatoes increases its competitiveness with nightshade. Nitrogen fertilizer applications during greenhouse production can also increase tomato competitiveness with nightshade. Our research also found that perennial eastern black nightshade serves as an overwintering host for cucumber mosaic virus. In Illinois, eastern black nightshade resistant to ALS-inhibitors has been identified. Eastern black nightshade has also been poorly controlled in glyphosate-resistant soybean systems. In this case, poor control is likely caused by nightshade growing under the soybean canopy and not being contacted by the herbicide and emergence after the glyphosate application. We evaluated glyphosate and carfentrazone susceptibility of eastern black nightshade accessions collected throughout the range. We found that accessions varied in their tolerance to low rates of glyphosate but that at full-field rates (1.12 kg/ha or above) there were no differences. Carfentrazone is a PPO-inhibitor that cause contact burn. Some accessions were killed by carfentrazone while other accessions were injured but recovered even at 46 g/ha, twice the recommended rate.

USING 5' RACE TO AMPLIFY AND SEQUENCE VELVETLEAF EPSPS. Aaron L. Waltz, Alex R. Martin, and Fred W. Roeth, and Don J. Lee, Graduate Research Assistant, Professor, Professor, and Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE 68583-0915.

Glyphosate is a widely used pesticide in US crop production. With a large percentage of soybean acres (approximately 70%), and a growing number of corn acres being treated with glyphosate, an estimated 100,000,000 field acres could be treated annually with glyphosate. Tolerance/resistance to glyphosate has been engineered and selected for in many crop and common research species, and at least eighteen glyphosate-resistant biotypes of six weed species now exist. One biotype, glyphosate-resistant goosegrass, has one single amino acid substitution in common with commercially available, glyphosate-resistant corn hybrids. The goal of this research is to amplify and compare regions of the EPSPS DNA sequence within weed species, initially concentrating on velvetleaf, a primary weed of production agriculture in Nebraska and the Great Plains. PCR primers were developed with database techniques by aligning several EPSPS sequences available through GenBank. Highly conserved amino acid and base pair regions within this enzyme make this a possibility. Initial attempts to amplifiy products from DNA were unsuccessful. It appears that at least one of the primers has multiple targets within the Arabidopsis genome. A technique known as 5' RACE (Rapid Amplification of cDNA Ends) is being utilized to target and amplify the 5' end of EPSPS within velvetleaf. This process involves isolation of RNA, reverse transcription to make cDNA, tailing of the cDNA with base pairs, and then PCR amplification using one RACE-specific primer and one gene-specific primer. The EPSPS gene sequence from important weed species may yield information about the EPSPS enzyme across species. EPSPS gene primers that produce gene-specific products across multiple species would be beneficial in weed population surveys. Sequence information can also be used in blotting procedures to investigate EPSPS gene families and copy number, and to examine EPSPS mRNA expression. Understanding and utilizing information about EPSPS in weed populations can be an important basis for future weed management programs.

EVALUATION OF *MICROSPHAEROPSIS AMARANTHI* FOR THE BIOLOGICAL CONTROL OF WATERHEMP. David A. Smith and Steven G. Hallett, Graduate Research Assistant and Associate Professor of Weed Science, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Waterhemp, *Amaranthus tuberculatus* Sauer., is a troublesome weed in Midwestern cropping systems. Herbicide resistant biotypes and a prolonged emergence period make waterhemp difficult to control. Waterhemp is dioecious and has extreme genetic variability. *Microsphaeropsis amaranthi* is a fungal pathogen isolated from *Amaranthus* sp. in Arkansas that has a narrow host range limited to the Amaranthaceae. Since *M. amaranthi* infects waterhemp, which is only part of the complex weed communities in Midwestern cropping systems, it is important to evaluate the potential for integration into current weed management practices. Three experiments were designed to examine different attributes of the fungus in order to evaluate its potential for further development as a bioherbicide for the control of waterhemp. Epidemiological experiments were designed to determine the optimum and limiting environmental conditions for the activity of the fungus. Herbicide interaction experiments were designed to investigate the potential for the fungus to be integrated into cropping systems with herbicide-dominated weed management strategies.

Tank-mix experiments were performed to see if conidial germination was directly inhibited by commonly used herbicides or adjuvants. Conidia were incubatedin solutions of herbicides and adjuvants for two hours and then potato dextrose broth was added to stimulate conidial germination. Conidial germination was counted under a compound microscope. Conidial germination was decreased by most adjuvants and herbicides, and most formulated glyphosate products completely hindered conidial germination. After testing several glyphosate formulation blanks and several different technical grade glyphosate salts, we found that the surfactants in glyphosate formulations were the major source of incompatibility with *M. amaranthi* conidia.

Since direct inhibition of *M. amaranthi* conidia by glyphosate products precluded the preparation of tank mix applications we examined split-applications of glyphosate and conidia on waterhemp seedlings in order to investigate the existence of a physiological interaction between the fungus and glyphosate. When glyphosate (at various concentrations) was followed by *M. amaranthi* ($3*10^6$ conidia/ml) one day later, waterhemp was predisposed to increased infection by the fungus, and greater dry weight reductions were found.

We tested a range of dew periods and temperatures that may be suitable for *M. amaranthi* to infect 3-4 leaf waterhemp. The optimum conditions for *M. amaranthi* impact were found using 18 hours of dew at 18 to 23^{o}C under which conditions, *M. amaranthi* caused girdling stem lesions and high levels of plant mortality. Infection and impact by *M. amaranthi* was severely limited by dew periods shorter than 12 hours, and only scattered infection was seen with a dew period of 6 hrs.

In conclusion, application of sub-lethal rates of glyphosate can predispose waterhemp to increased infection and impact by *M. amaranthi*. Direct inhibition of *M. amaranthi* conidia by glyphosate products, however, will make the exploitation of this interaction in the field problematic. The environmental requirements of this fungus for optimal activity are unlikely to be frequently encountered in the field when waterhemp control would be desired.

SOYBEAN CYST NEMATODE REPRODUCTION ON PURPLE DEADNETTLE UNDER GREENHOUSE CONDITIONS. R. Venkatesh, S. K. Harrison, E. E. Regnier, and R. M. Riedel, Postdoctoral Research Associate, Associate Professors, Department of Horticulture and Crop Science, and Professor, Department of Plant Pathology, The Ohio State University, Columbus, OH 43210.

Soybean cyst nematode (SCN) is the most economically important soybean pathogen in the United States. Purple deadnettle is an obligate winter annual weed of no-tillage crop fields in the Corn Belt, and an alternate host of SCN. Greenhouse experiments were conducted to investigate the effects of purple deadnettle population density and removal time on SCN reproduction in a controlled environment. Seeds of PDN were sown in 500-cm^3 styrofoam cups containing sand. After seedling emergence, purple deadnettle seedlings were thinned to densities of 1, 2, and 4 seedlings per cup. Controls contained either no plants or 1 to 2 plants per cup of Corsoy 79 soybean (susceptible). Three to four weeks after emergence, each cup was inoculated with 4,000 to 5,000 SCN eggs + juveniles of race 3 SCN, the most prevalent race infesting soybean fields in Ohio. Plants were then removed at 10, 20, 30, or 40 days after inoculation (DAI). At each removal time, soil and roots were extracted for determination of SCN eggs + juveniles/200 cm^3 of soil. The treatments were arranged factorially in a randomized complete block design with 6 replications and experiment was conducted twice. SCN counts were transformed to $\log_{10}(x+1)$ values to standardize the variance prior to ANOVA, and the means were back-transformed for presentation. Mean SCN reproduction was 2.3 to 4.2 times greater on PDN than on Corsoy 79, but SCN egg counts did not differ significantly among PDN population densities. The main effect of plant removal time on SCN reproduction was highly significant. Plant removal treatments of 10, 20, 30, and 40 DAI had mean SCN egg concentrations of 3, 69, 886, and 1746 eggs + juveniles/200 cm^3 soil, and nonlinear regression analysis indicated that egg counts increased logarithmically between 20 and 30 DAI. These studies indicate that under optimal conditions, SCN is capable of completing its life cycle on PDN within a 20 to 30 day period. In SCN-infested field soils, early control of PDN seedlings that emerge in the fall may thus be necessary to avoid SCN reproduction and rapid increases in SCN inoculum levels.

ALLELOPATHIC POTENTIAL OF BIENNIAL WORMWOOD. Mark G. Ciernia and George O. Kegode, Research Specialist and Asst. Professor, Dept Plant Sciences, North Dakota State Univ., Fargo, ND 58105.

Biennial wormwood (*Artemisia biennis* Willd.) is native to northwest U.S. and western Canada and has become a problematic weed in several crops. In cultivated fields, biennial wormwood forms huge patches which adversely affect surrounding vegetation and crop production. A greenhouse study was conducted to explore the allelopathic potential of biennial wormwood plant parts. Biennial wormwood plants of different sizes were partitioned into leaves, roots, and stems, then dried and mixed into soil. Crop species, corn, soybean, sunflower, and wheat, and weed species, green foxtail, hairy nightshade, redroot pigweed, and wild oat, were seeded into amended soil and plant height and fresh weight was assessed at 14 days for crops and 21 days for weeds. Wheat was the most sensitive crop. Soil amended with biennial wormwood root biomass produced a 21% reduction in plant height and a 57% reduction in fresh weight of wheat compared to unamended soil. Hairy nightshade was the most sensitive weed species. Soil amended with biennial wormwood root biomass reduced plant height by 60% and fresh weight by 80% compared to unamended soil. Plant parts from biennial wormwood plants that were 45 cm tall at harvest were the most phytotoxic to both crop and weed species. Soil amended with biennial wormwood leaf and stem biomass from 15-cm-tall plants produced increased hairy nightshade plant height and fresh weight compared to unamended soil. In contrast, soil amended with leaf or stem biomass from 45-cm-tall plants produced hairy nightshade plants 40 and 67% shorter and with 67 and 82% less fresh weight compared to unamended soil. Soil that was amended with 45-cm-tall biennial wormwood plants was more phytotoxic to hairy nightshade than to other weeds. Hairy nightshade plant height and fresh weight was reduced by 79 and 93%, respectively in amended soil compared to unamended. Based on this study biennial wormwood appears to produce allelochemicals that are phytotoxic to some weeds and crops. Isolation, characterization, and detailed determination of phytotoxic allelochemicals is needed to understand factors contributing to biennial wormwood spread.

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WEED SEEDLING EMERGENCE PATTERNS IN NORTH DAKOTA ROW CROPS. George O. Kegode and Mark G. Ciernia, Assistant Professor and Research Specialist, Dept. of Plant Sciences North Dakota State Univ., Fargo, 58105.

Understanding weed seedling emergence patterns aids in developing weed management tools that exploit vulnerable stages in weeds. Research was conducted at Fargo and Prosper, ND from 2001 to 2003 to study weed emergence patterns in chickpea, corn, dry edible bean, field pea, potato, soybean, and sunflower. A further objective was to study the emergence pattern of new invasive/aggressive weeds: biennial wormwood (*Artemisia biennia*), Canada thistle (*Cirsium arvesnse*), and lanceleaf sage (*Salvia reflexa*). This study was conducted using untreated plots within experiments designated for weed control studies. Upon seeding of crops, four permanent quadrats, each 0.1 m^2, were placed within untreated plots and weed emergence was monitored and recorded twice weekly until late July or canopy closure. Redroot pigweed (*Amaranthus retroflexus*) was the dominant weed in all crops except dry edible bean in 2003 and accounted for 40 to 77% of total emerged weeds, followed by green and yellow foxtails (*Setaria viridis* and *S. pumila*) which accounted for 17 and 51% of total emerged weeds. In general, emergence patterns for redroot pigweed and the foxtails were similar with emergence ceasing in early July. Lanceleaf sage emergence pattern among crops was similar to redroot pigweed and foxtail and generally ceased by early July. Biennial wormwood and Canada thistle emergence was relatively slower compared to other weeds and appeared to cease in late July. Our research suggests that lanceleaf sage will probably be easier to control within crops than biennial wormwood and Canada thistle because its emergence pattern is similar to known established weeds such as redroot pigweed and foxtail, whereas biennial wormwood and Canada thistle have prolonged emergence periods. A better understanding of emergence of biennial wormwood and Canada thistle in the field will improve our ability to manage these species.

MODELING EMERGENCE OF TROPICAL WEEDS. Friday Ekeleme, David Chikoye, David Archer, and Frank Forcella, Assistant Professor, Research Scientist, Agricultural Economist, and Research Agronomist, Michael Okpara University of Agriculture, Umudike, Nigeria; International Institute of Tropical Agriculture, Ibadan, Nigeria; and USDA-ARS, Morris, MN 56267.

Weed control is a major production cost in most crops in tropical cropping systems. Due to competing demands on time during the growing season family labor is often not available when weeds are most damaging to crops. Weeds could be managed better if farmers understood their emergence patterns. Emergence models were developed for two important weeds in cropping systems of Nigeria and other tropical areas. These species were tropic ageratum (*Ageratum conyzoides*), an annual broadleaf, and cogongrass (*Imperata cylindrica*), a rhizomatous perennial. The models were developed using the soil hydrothermal time concept and five years of seedling emergence data for tropic ageratum at Ibadan, and two years of cogongrass shoot emergence data at Umudike. Hydrothermal time was calculated from soil temperature and soil water potential at 2 cm depth, which were simulated with the SHAW (Soil Heat and Water) model using required weather data collected at the two locations. Base temperature and base soil water potential were 28 C and –0.02 MPa for tropic ageratum, and 25 C and –0.01 MPa for cogongrass. For each species a Weibull function was fitted to cumulative percentage emergence and hydrothermal time. The Weibull functions that best described the emergence of tropic ageratum and cogongrass were $Y = 100 * [1\text{-}e^{0.0054} * \theta HT^{1.4268}]$ and $Y = 100 * [1\text{-}e^{0.000023} * \theta HT^{2.8575}]$, respectively. The model for tropic ageratum not only simulated emergence adequately at Umudike ($r^2 = 0.85$), but also for an independent set of data from Los Banos, Philippines ($r^2 = 0.89$). The cogongrass model adequately simulated emergence in corn/cassava plots weeded twice and five times at Ibadan. The model for tropic ageratum may be most useful in tropical locations where conditions approximate those in Nigeria. Additionally, the cogongrass model has some merit and may help to set the stage for further analysis on emergence patterns and management of cogongrass.

WEED FLORA CHANGES IN ARABLE CROPS IN TURKEY. Husrev Mennan and Bernard H. Zandstra, Visiting Scientist and Professor, Department of Horticulture, Michigan State University, East Lansing MI 48824.

Density of single or several weed species can change during a long period of time. Purification of seed, choice of crops, rotations, sowing time and techniques, soil management, harvest time, fertilizing, chemical and mechanical weed control methods are important factors that influence weed flora. It is often difficult to separate the effects of one factor from another due to reciprocal interactions between all these factors. Herbicide selection, crop rotations, and fertilizer use may effect changes in weed flora.

The data for the present study were obtained from the weed surveys of wheat, onion and corn fields of Middle Black Sea Region of Turkey. The first surveys in winter wheat, onion and corn were carried out in 1992, 1976 and 1973 respectively. The second surveys in winter wheat, onion and corn were conducted by Mennan in 2000, 1999-2000 and 2001-2002 respectively, using the same method described in the first surveys. In both surveys, the samples were collected randomly from 1 m^2 area and the number of frames was adjusted depending on field size. The number of weed individuals in the sample frame was pooled. Thus, frequency and density of each weed species were calculated. In addition, a similarity index between the two surveys was calculated by using the equation SI=2C/(A+B) for each crop, where SI=similarity index, A=number of weed species in the first survey, B= number of weed species in the second survey, and C=number of similar weed species in both surveys (Odum, 1971).

There were few changes in the density and species of weeds in wheat fields between 1992 and 2000. Weed similarity index between the two surveys was 0.90. The background information on cropping practices in our study fields revealed that application rates of phenoxy herbicides have been reduced but some other active ingredients such as sulfonylureas have increased. Farmers had applied herbicides against broadleaves in Middle Black Sea Region of Turkey. Grasses such as wild oat, blackgrass, and canarygrass gained more importance as a result of using herbicides with similar modes of action. In addition, ivyleaf speedwell, bifra (*Bifora radians* Bieb.), catchweed bedstraw, wild mustard, and field bindweed remained common within the decade in spite of extensive use of herbicides.

In corn, the number of weed species decreased from 43 to 30 between the years 1973 and 2001. Weed similarity index between two surveys was 0.79. Field bindweed, barnyardgrass, redroot pigweed, common lambsquarters, johnsongrass and bermudagrass were important weed species in the first survey in terms of density and frequency. Velvetleaf, black nightshade, wild buckwheat, common purslane, puncturevine, blackgrass, jimsonweed, European heliotrope, corn buttercup, catchweed bedstraw and mugwort were more important in the second survey. While mugwort was not found in the first survey, density of this species reached 2.78 plant/m^2 in the second survey.

The number of weed species was completely different in the two surveys in onion. Weed similarity index between two surveys was 0.41. The frequencies of common lambsquarters, black nightshade, and European heliotrope decreased dramatically. In contrast, frequencies of field bindweed, redroot pigweed, common cocklebur, Canada thistle, wild mustard, catchweed bedstraw and bifra increased. After the late 1970’s, linuron, pyrazon and monolinuron, and in early 1990’s pendimethalin and oxyfluorfen have been used intensively in onion fields. These herbicides controlled successfully some broadleaved and grass weeds. But, vegetative reproducing weed species such as field bindweed and Canada thistle were not controlled and gained more importance.

POPULATION DIFFERENCES IN WATERHEMP TREATED WITH GLYPHOSATE AND LACTOFEN. Jianmei Li, Reid J. Smeda, and Jimmy D. Wait, Research Specialist, Associate Professor, and Research Associate, University of Missouri, Columbia, MO 65211.

Common waterhemp (*Amaranthus rudis*) is a widely distributed and troublesome weed to manage in Missouri crops. Past herbicide practices have led to selection of biotypes resistant to sulfonylureas, imidazolinones, triazines, glyphosate, and diphenyl ethers. The introduction and wide spread adoption of glyphosate-resistant crops (72% of Missouri soybean production area in 2002) has permitted a new and powerful tool to manage waterhemp, but may lead to new management challenges. This study investigated differential sensitivity of common waterhemp biotypes to glyphosate as well as lactofen. Waterhemp seed was collected from 100 sites (biotypes) throughout Missouri in the fall of 2002. Dose response curves to glyphosate and lactofen were developed with a waterhemp biotype (Bradford) known to be sensitive to both herbicides using plant dry weight. The I_{50} for the Bradford biotype in response to glyphosate and lactofen was 0.06 kg ae/ha and 0.016 kg ai/ha, respectively. Seeds of each biotype were grown under greenhouse conditions and up to 25 plants from each biotype were treated at 10- to 13-cm with the above rate of glyphosate or lactofen. Using the Bradford biotype for comparison, the mean dry weight of 10 biotypes was higher, 41 biotypes were similar to, and 49 biotypes were lower than the Bradford biotype at the 90% confidence interval. Plant dry weight response within each biotype was highly variable, and ranged from 90% less than to 100% greater than the Bradford mean plant response. For lactofen, the mean dry weight of 3 biotypes was higher, 17 biotypes were similar, and 80 biotypes were lower than the Bradford biotype at the 95% confidence interval. Individual plant dry weight ranged from 90% less than to 10% greater than the Bradford mean response. Greater variation in waterhemp response may contribute to management challenges for glyphosate compared to lactofen.

GROWTH ANALYSIS OF GIANT CHICKWEED IN ALFALFA AND BARE GROUND. Michael P. Crotser, University of Wisconsin-River Falls, Assistant Professor of Agronomy, Plant and Earth Science Department, River Falls, WI, 54022.

Weedy giant chickweed has been confirmed by county agents in pastures, forages, and turfgrass areas in several Wisconsin counties. Due to the morphological similarities between the chickweed complex, presence and distribution of giant chickweed has likely been underestimated. Currently, no literature exists to characterize giant chickweed as weed. The objective of this study was to characterize giant chickweed growth in isolation and as influenced by interspecific interference with alfalfa. The study was conducted at the University of Wisconsin-River Falls Mann Valley Farm to model giant chickweed biomass, leaf area, leaf area ratio, net assimilation rate and relative growth rate development. The experiment was a split-plot design with four replications. Sub-plot treatments were weeks of giant chickweed growth and whole-plot treatments were giant chickweed grown on bare ground or in established alfalfa. Growth analysis parameters were analyzed using the ANOVA procedure of SAS and means, if statistically different, were separated using Fisher's protected LSD test.

Biomass accumulation, leaf area, leaf area ratio, net assimilation rate and relative growth rate of giant chickweed were similar over years and data were combined for analysis. For both the bare ground and alfalfa environments giant chickweed biomass increased over time with the greatest mass observed at 12 weeks after planting. Similar increases were observed for leaf area over time, however leaf area did not increase after weeks seven and eight for the bare ground and alfalfa environments, respectively. In general, net assimilation rate of giant chickweed was positive for the first six weeks of growth. However, many of the recorded net assimilation rate values late in the season were negative, suggesting carbon loss from the plant. For the latter harvest dates the lower leaves on giant chickweed would often senesce and abscise from the plants. However, leaf area ratio values suggest the loss of lower leaves over time did not have an overall impact on giant chickweed leafiness. For giant chickweed, relative growth rate values were not apparently influenced by the growth stage of giant chickweed nor changes in average weekly temperature. Based on net assimilation rate values, carbon loss may be better described by increased rates of respiration, rather than reductions in plant leafiness (i.e. leaf area ratios). No statistical differences were observed in chickweed growth parameters for plants grown on bare ground when compared plants grown in alfalfa. This suggests that alfalfa competition itself does not negatively affect giant chickweed growth and developments.

MORPHOLOGICAL VARIATION IN WORLD COLLECTIONS OF VELVETLEAF. Lynn M. Sosnoskie* and John Cardina, The Ohio State University, and Sajal Sthapit, The College of Wooster, Wooster.

Our lab characterized the morphological and phenological variation present in 83 velvetleaf (*Abutilon theophrasti*) accessions collected in Asia, Japan, India, Europe, Eastern Africa and North America throughout the 20th century. Measurements taken to gauge the diversity in growth and development in the species included: initial seed weight, stem height at 3, 7 and 11 weeks, leaf size at 3, 7 and 11 weeks, stem and petiole color, time to flowering, time to first capsule maturity, stem height at flowering, height to first mature capsule, basal stem diameter, number of capsules, and capsule size and color. Significant differences between accessions were observed for most of the examined variables ($P<0.01$). Preliminary analyses indicate that accessions producing yellow capsules were taller and longer-lived than their brown-colored counterparts were ($P<0.01$). This finding supports a previous study's assertion that the yellow-colored varieties were originally selected for use as a fiber crop: i.e. increased stem yield resulted in longer lengths of lignified tissue. The accessions producing brown-colored capsules exhibited greater reproductive output, as measured by the number of capsules and the number of seed-containing valves per capsule, a desirable trait in weedy species. Using capsule color as the independent variable, Discriminant Analysis was able to correctly classify 96% of the observations by the remaining characters, further suggesting that the yellow- and brown capsuled accessions varied, significantly, with respect to their morphology and phenology. Current studies are examining the degree of genetic variation present in these populations.

INTRASPECIFIC GENETIC VARIATION IN COMMON WATERHEMP (*AMARANTHUS TUBERCULATUS*) SEED DORMANCY REGULATION. Ramon G. Leon and Micheal D. K. Owen, Graduate Research Assistant and Professor, Department of Agronomy, Iowa State University, Ames, IA 50011.

Seed dormancy is one of the most important adaptive traits for the success of many weeds. Changes in seed dormancy level dramatically affect seed bank dynamics and consequently seedling emergence patterns (in time and space) thus having a direct impact on weed management. Common waterhemp (*Amaranthus tubeculatus* (Moq.) J.D. Sauer.) is a problematic weed in corn and soybeans because apart from the evolved resistance to herbicides, it has variable emergence patterns. There is contradictory information describing the emergence patterns of common waterhemp, and it is not clear if it is a late, early or just variable emerging species. In previous studies for a population collected near Ames, IA, we showed how environmental signals such as light exposure, chilling, and temperature fluctuation changed the dormancy level of common waterhemp seeds. This environmental seed dormancy regulation allows great plasticity for the occurrence of different emergence patterns depending on the environmental conditions. Because common waterhemp is a dioecious species (obligate outcrosser), it has a great potential genetic variability among populations. Therefore, it is reasonable to think that the different emergence patterns observed in the field could be also explained by the existence of different seed dormancy regulatory mechanisms among populations. We tested this hypothesis by comparing changes in seed dormancy levels in three common waterhemp populations. Two populations were collected in crop fields near Ames, IA, and near Everly, IA. The other population was collected from a pristine area in Highland County, OH. In order to minimize the environmental effect on seed dormancy, seeds from the three populations were stratified and planted in pots. The pots were placed in growth chambers under the same conditions to produce new seeds. The seeds produced were collected and used in the experiments. Seeds were incubated at 4 and 25 C in dry and wet conditions for 3 wk. Then, germination tests were conducted to determine differences in seed dormancy levels. The Ames population showed seed dormancy reductions after incubation in wet conditions, and the germination was around 50%. The germination of seeds incubated in dry conditions was between 10 and 25%. The Everly populations only reduced the seed dormancy level after incubation at 25 C and wet conditions showing germination close to 60%, which was almost twice the germination shown by the other treatments. In the case of the Ohio population, no differences between treatments were observed and the germination was above 85%. Because there was an interaction between wet conditions and temperature, we conducted another experiment to analyze in more detail the effect of those factors on seed dormancy. The seeds of the three populations were incubated at 4 and 25 C in wet conditions from 0 to 8 wk. The dormancy level of the Ames population decreased proportionally to the incubation period at the two temperatures. The Everly population only reduced the dormancy level when incubated at 25 C. The Ohio population did not respond to the incubation treatments and showed more than 85% germination for all treatments. The results of this study clearly showed that there is intraspecific genetic variation in common waterhemp seed dormancy regulation. These results highlight the problems that models based on studies conducted on only one population could have for accurately predicting weed emergence of other populations for species with high genetic variability. In addition, it is likely that several weed populations have seed dormancy traits that make them more difficult to manage than others. This raises the question about how agricultural practices such as tillage and herbicide use could be affecting the evolution of complex seed dormancy traits that are undesirable in sustainable agroecosystems.

EFFECT OF CARBON SEQUESTARTION PRACTICES ON WEED POPULATIONS. 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.

Carbon sequestration has been a hot topic lately due to the increased awareness of greenhouse gases and the potential of global warming. Michigan State University is part of a consortium consisting of nine universities and a national laboratory investigating the potential for agricultural soils to be a sink for greenhouse gases. Potential alternatives to increase soil carbon in agricultural systems are to use no-till practices, cover crops, and/or add manure amendments. However, manure often contains weed seeds which may cause increased weed populations or population shifts resulting in higher weed control expenses.

Studies were conducted at Kellogg Biological Station near Hickory Corners, MI and at East Lansing, MI to determine the effect different carbon sequestration practices may have on weed populations. Experiments conducted at KBS investigated the influence of organic and conventional systems, and a no-till cropping system. Rye and clover cover crops were used with certain crops to try to increase soil carbon and decrease weed pressure in all three systems. Cover crop and weed biomass were harvested directly before any tillage operation or herbicide application.

The experiment at East Lansing examined the possibility of using a rye cover crop with or without either manure or compost to increase soil carbon in a silage corn/soybean cropping system. Silage corn and soybean cropping systems return low amounts of organic carbon back to the soil. Manure and compost was applied in April and December of 2002 and in April of 2003. Weed biomass and populations were determined after herbicide application at East Lansing in 2003. Glyphosate was applied on May 8 as a preplant application, and June 19 as a postemergence application. Samples were collected on May 13 and June 21.

Compost had a significant effect on weed densities and biomass with common lambsquarters being affected the most on May 13. Rye + compost had higher common lambsquarters populations and biomass than all other treatments on June 21.

THE EFFECT OF NITROGEN ON WEED EMERGENCE AND GROWTH. Amy E. Guza, Karen A. Renner, and Adam S. Davis, Graduate Assistant, Professor, and Research Associate, Department of Crop and Soil Science, Michigan State University, East Lansing, MI 48824.

In 2003, a field study was conducted to determine the effect of nitrogen on the emergence and growth of five weed species. Weed species included giant foxtail, redroot pigweed, velvetleaf, common lambsquarters, and ladysthumb smartweed. Weeds were seeded April 15, April 29, and May 22, 2003 in a 1 m^2 area. At each seeding date, 0, 56, 112, or 168 kg N/ha of was preplant incorporated to a 5-cm depth prior to weed seeding. The experiment was a split-plot design with seeding date as the main plot, nitrogen rate as the sub-plot (3 m by 9 m), and weed species as the sub-sub plot. Soil samples were taken to a depth of 7.6 cm just prior to weed seeding and at one, two, and three weeks after seeding. Soil samples were analyzed for nitrate and ammonium concentrations using an extract of 1 N KCl and were analyzed colormetrically. Weed seedling emergence and growth stage were recorded for six weeks after planting to evaluate the effect of nitrogen on weed emergence and growth.

Initial nitrate-N and ammonium-N concentrations were 5 and 3 kg ha^{-1}, respectively, on April 15; 7 and 3 kg ha^{-1}, respectively, on April 29; and 9 and 5 kg ha^{-1}, respectively, on May 22. One week after nitrogen was applied on April 15, the amount of total inorganic N (nitrate-N + ammonium-N) was similar to the amount of nitrogen applied. However, in samples collected in the second and third week after planting, total inorganic N did not reflect the nitrogen that was applied. On April 29 and May 22 planting dates, the available N was less than expected for all sampling dates. Giant foxtail and redroot pigweed emergence and growth did not increase with the addition of N, regardless of planting date. At each planting date, emergence of common lambsquarters and ladysthumb smartweed increased with the addition of N. Common lambsquarters, ladysthumb smartweed, and velvetleaf growth increased with the addition of nitrogen, regardless of planting date.

ANNUAL WEED EMERGENCE AND SEED PRODUCTION AT FOUR SOWING TIMES IN CORN. Kathrin Schirmacher* and J. Anita Dille, Graduate Research Assistant and Assistant Professor, Kansas State University, Manhattan, KS 66506.

Few competition studies have been conducted in Kansas. Yet WeedSOFT®, a Decision Support System (DSS), that incorporates information on weed and crop growth, has been introduced in the state. The current biological database in the program has been derived from expert opinion. The objective was to compare the time of emergence and seed production of four annual weed species established at four different planting times in corn to generate a local database of information to be used in the Kansas version of WeedSOFT®. Field studies were conducted with common sunflower, giant foxtail, shattercane, and velvetleaf near Manhattan, Kansas in 2001 and 2002. Weeds were sown at planting time (V0), VE, V1, and V3 corn growth stages.

Range of emergence for planting times V0 and VE grouped common sunflower, giant foxtail, shattercane, and velvetleaf together. Decreasing soil moisture throughout the growing season caused greater variability in emergence of planting times V1 and V3 with few or no replicates emerging for all weed species. In Kansas, emergence of weeds was found to be highly contingent with rainfall patterns and explains the relatively earlier emergence of weeds in 2002 as opposed to 2001. Seed production was linearly related to end-of-season weed biomass with pooled models across years for all weed species. Maximum seed production for common sunflower was 33,900 seed plant^{-1} in 2002 and 8,100 seed plant^{-1} for velvetleaf in 2002. Rates of seed production were similar with 23.2 and 24.4 seed g^{-1} of weed biomass for common sunflower and velvetleaf, respectively. Rate of seed production for grasses was highest for giant foxtail with 296.5 seed g^{-1} and then shattercane with 26.5 seed g^{-1} across years.

Early emerging plants produced greater biomass and thus, had a higher level of seed production. Late-emerging weeds were still able to produce seed and contribute to the future dynamics of the weed population. The linear relationship between seed production and end-of-season biomass across years allows for estimating potential weed seed production.

WEED COMPETITIVE INDICES: CORRELATION WITH SOIL WATER DEPLETION AND GROWTH PARAMETERS. F. William Simmons, Nicholas T. Fassler and Chris D. Kamienski. Kohler, Associate Professor, Graduate Research Assistant, and Graduate Research Assistant, Natural Resource and Environmental Science and Crop Science Dept. University of Illinois, Urbana, IL 61801.

Herbicide selection and postemergence application timing is often based on perceptions of weed species composition, weed size, and weed density evaluations. In some cases decision software utilizes relative weed competitive indices (CI) to estimate critical periods of weed interference. Current estimates of weed CI are based on expert opinion. Our experiment was designed to investigate the potential correlation of soil-water depletion, weed biomass, and weed leaf area index (LAI) with existing CI values. An initial greenhouse study was conducted using seven weed species (giant foxtail, common lambsquarters, tall waterhemp, palmer amaranth, velvetleaf, cocklebur, and giant ragweed) planted in large 21-l pots instrumented with time domain reflectometry probes. Wetting and soil-water depletion cycles were conducted periodically as the weeds developed over a 60-d period. Volumetric water content was measured continuously at 2-h intervals throughout the experiment. Rank order of LAI agreed fairly well with existing CI values but was not a linear relationship. Biomass accumulation was not related to CI indices, particularly since the amaranthus species accumulated the most biomass but have current CI values much less than either cocklebur or giant ragweed. Soil water depletion rates were greatest for giant ragweed and least for giant foxtail but were nearly the same for all other species. Unique weed size-water depletion rate relations were identified for individual species as well as threshold soil-water contents where weed species wilting occurs.

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 in a corn-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; in addition field cultivation was conducted in spring following all chisel plow treatments. Weekly weed assessments were taken for seven weeks after planting in 2002 and 2003. Data collected included weed species, weed species number, average weed heights, and weed node or leaf number. These assessments were made in permanently established 0.25 meter square quadrats. 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. Results indicate that tillage and crop rotations influence weed population dynamics. As levels of tillage disturbance increase, velvetleaf densities decrease and densities of small seeded broadleaves increase. Additional studies will determine how tillage rotations can be utilized in an integrated weed management system.

WEED BEHAVIOR FOLLOWING LOSS OF APICAL DOMINANCE. Hank J. Mager, Bryan G. Young, John E. Preece, and Joseph L. Matthews, Graduate Research Assistant, Associate Professor, Professor, and Researcher, Southern Illinois University, Carbondale, IL 62901.

A possible result of a failed postemergence herbicide application is compensatory shoot growth from previously inhibited axillary buds following the death of the apical shoot. The objective of this research was to determine the efficacy of glyphosate and lactofen on ivyleaf morningglory, common waterhemp, and giant ragweed following the loss of apical dominance. Plants were grown in the greenhouse to a height of 15 cm at which time the apical shoots were removed by cutting just above the cotyledonary node. Clipped plants were allowed to regrow to 15 cm then were treated with lactofen or glyphosate. Herbicide treatments were also applied to intact plants that were 15 cm in height for comparison.

Weed response to herbicides following the loss of apical dominance varied by weed species and herbicide. Ivyleaf morningglory that regrew following the loss of apical dominance was more susceptible to glyphosate than intact plants. Conversely, intact ivyleaf morningglory plants were more susceptible to lactofen than clipped plants. There was little difference in response to glyphosate between clipped and intact common waterhemp plants. However, clipped common waterhemp plants were more sensitive to lactofen than intact plants. Following the loss of apical dominance, giant ragweed was less sensitive to both glyphosate and lactofen.

EMERGING BLUE-GREEN ALGAL PROBLEMS IN THE NORTH CENTRAL REGION.
Carole A. Lembi, Kathryn Wilkinson, and Alejandra Cota, Professor, Graduate Research Assistant, Undergraduate Assistant, Department of Botany and Plant Pathology, Purdue University, W. Lafayette, IN 47907.

Planktonic blue-green algae (Cyanobacteria) have been problems in eutrophic lake systems around the world for many years. As elsewhere, the dominant genera in the Midwest are *Anabaena*, *Aphanizomenon*, and *Microcystis*. The reduction of blooms of these organisms has been the goal of numerous watershed management efforts and copper treatments through the years. New problem blue-greens have appeared in the Midwest within the past 10 years. For example, the discovery of blooms of the toxic planktonic species *Cylindrospermopsis raciborskii* in Ball Lake and Eagle Creek Reservoir in Indiana in 2001 spurred a great deal of concern. Although copper treatments have prevented population buildups, there is concern that this organism may develop resistance. In addition, the mat-forming (*Oscillatoria*) and gelatinous mass-forming (*Nostoc*) blue-greens appear to have an inherent tolerance to copper. An additional concern is the potential for buildup of copper in bottom sediments. We have found that diquat and endothall can provide contact control of the mat-formers, but restrictions on use of treated water under some circumstances can limit their application. Two approaches are necessary for effective management of these organisms. The first is to determine the environmental parameters that regulate growth and the second is the development of new control strategies.

SENSITIVITY OF MAT-FORMING CYANOBACTERIA TO A POTENTIAL BIOLOGICAL CONTROL AGENT, BACTERIUM SG-3. Kathryn J. Wilkinson, H. Lynn Walker, and Carole A. Lembi, Graduate Research Assistant, Professor, Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47905 and School of Biological Sciences, Louisiana Tech University, Ruston, LA 71270.

Mat-forming cyanobacteria (blue-green algae) are an increasing problem in bodies of water, especially small, shallow ponds. These organisms tend to be difficult to control with copper compounds; therefore, the development of a biological control agent to manage cyanobacteria mats would be extremely useful. Bacterium SG-3 (NRRL B-30043) has been shown to lyse a number of planktonic species of cyanobacteria including bloom-forming species of *Anabaena* and *Oscillatoria*. The objective of this research was to determine the sensitivity of mat-forming cyanobacteria isolated from ponds throughout Indiana to bacterium SG-3. Nine isolates of mat-forming cyanobacteria representing seven species within the genera *Oscillatoria*, *Lyngbya*, and *Phormidium* were tested. Plugs (0.5 cm diameter) were cut from mats of cyanobacteria, inoculated with liquid cultures of SG-3, and incubated as static cultures. Three rates, determined as PFU/mL, of SG-3 inoculum were used. All species tested were sensitive to treatment and exhibited 71-100% reduction in dry weight at the highest concentration of SG-3. However, certain species of mat-forming cyanobacteria were highly sensitive to a low treatment rate while others required a larger effective dose. For example, over the three treatment rates, dry weight reduction of *Oscillatoria amoena* ranged from 99.6% to 100% whereas the reduction in dry weight of *Phormidium ambiguum* ranged from 33% to 84%. Although results varied among and within species, they indicate that this bacterium could have potential for use as a biological control for mat-forming cyanobacteria. Light microscopic observations indicate that SG-3 does not penetrate the cyanobacteria cells. Currently, we are studying the possible causes of the observed cell lysis.

IMPACT OF WEED REMOVAL TIMING ON GLYPHOSATE-RESISTANT CORN (*Zea mays*).
Chad L. Smith and Reid J. Smeda, Graduate Research Assistant and Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211

Weed removal timing in corn is critical to minimize competition for available resources. Although many studies have focused on the density of weeds and/or length of time weeds compete in corn, few competition studies have considered implications on nitrogen availability. The objective of this experiment was to compare weed removal timing to in-season corn leaf nitrogen and the resultant grain yield. Field studies were conducted in central and northeast Missouri. Treatments included POST glyphosate applications at different weed heights and additional applications to maintain weed-free conditions the remainder of the season. A chlorophyll meter (Minolta® SPAD-502) was used to record leaf nitrogen in selected treatments at 15-day intervals following weed removal until plant senescence. At both locations, glyphosate applications on small grasses, broadleaves, or a mixture of weeds were important to grain yield. In central and northeast Missouri, grain yield was reduced 21% and 9% respectively, by delaying glyphosate applications until broadleaf weeds reached 20 - 25 cm. However, yield reduction from grass pressure was only up to 8% when application was delayed until the grasses reached 30 cm. Grain yield was optimal when the initial glyphosate application was made on 5 - 10 cm weeds followed by a second application, versus an initial application on 10 - 15 cm weeds or later. Corn leaf nitrogen was consistent in plants up to silking, and then declined. At central Missouri, where rainfall was limited, corn leaf nitrogen was an accurate prediction tool of grain yield following weed competition. At northeast Missouri, where rainfall was timely, grain yield was similar for most treatments where corn leaf nitrogen was measured. Therefore, leaf nitrogen differences between treatments were minimal.

WEED GROWTH AND CORN 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.

The extent that weeds impact crop growth is affected by weed species and the time when the interaction between weed and crop plants occur. In 2001, 2002, and 2003, the effect of weed growth on corn yield was examined in Michigan. Weeds were planted at four different timings based on corn growth stage; corn planting (cohort one), corn emergence (cohort two), V1 corn (cohort three), and V3 corn (cohort four). Cohort two was not planted in 2002 due to heavy rainfall and rapid corn emergence. Weeds were planted at a density of 10 plants per meter. Maximum weed volume was used to compare weed growth between three weed species; giant foxtail, velvetleaf and common lambsquarters. The effect of weed species and weed emergence time on corn growth was determined by corn yield.

Giant foxtail growth was similar between cohorts one and two in 2001, one and three in 2002, and was greater than later cohorts. Giant foxtail growth was greater with cohort one compared to other cohorts in 2003. Velvetleaf growth was greatest with cohort one each year. In 2001, cohort two had greater velvetleaf growth than cohort three and cohort three had greater growth than cohort four. In 2003, velvetleaf growth was similar between cohorts two, three, and four. No differences in common lambsquarters growth were observed in 2001. In 2002 and 2003, cohort one had the greatest common lambsquarters volume and there were no differences between the other cohorts.

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. Weed competition did not affect corn yield in 2003.

SYNERGISM 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.

During the summers of 2002 and 2003, the interaction between mesotrione and photosynthetic inhibitors, specifically Photosystem II (PS II), was investigated at multiple sites in Nebraska. Since mesotrione inhibits the 4-HPPD enzyme and as a result, carotenoid biosynthesis, its mode of action (MOA) is complementary to the MOA of the PS II class of herbicides. Greater control of problematic weeds occurs from this complementary interaction. When the observed response from two herbicide's joint application is greater than the expected response, it is termed synergism. Research was conducted to investigate whether this interaction was synergistic across species and rates and also, to quantify the degree to which synergism was seen. Mesotrione was tested at six different rates: 4.4, 8.8, 17.5, 35.0, 70.0, and 105.1 g ai/ha. The PS II herbicides tested were atrazine, at rates of 140.1, 280.2, and 560.4 g ai/ha, metribuzin at 26.3, 52.5, and 105.1 g ai/ha, and bromoxynil, at 70.1 and 140.1 g ai/ha. Treatments consisted of either mesotrione alone, a PS II alone, or a combination of the two. Percent chlorosis and 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 $\alpha = 0.05$. Synergistic activity occurred between mesotrione and PS II inhibitors with all of the above weed species. Results from 2002 reveal that 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. With respect to Palmer amaranth, synergism occurred at both 6 DAT and 12 DAT. At 12 DAT, the percent control achieved with mesotrione (17.5 g ai/ha) alone was 39% and was 28% for bromoxynil (70.1 g ai/ha) alone; however, the observed percent control for the combination was 95%. Initial results from 2003 appear to generally concur with those from 2002.

MESOTRIONE AND ATRAZINE COMBINATIONS APPLIED PREEMERGENCE IN CORN.
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.

The herbicide mesotrione is effective in controlling many troublesome broadleaf weeds. Previous field trials have reported greater weed control in corn when mesotrione is combined with atrazine. A field experiment was conducted in 2002 and 2003 at seven sites each year to determine the optimum rates of mesotrione and atrazine applied preemergence for control of common lambsquarters, velvetleaf, common ragweed, and giant ragweed. 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. The study was designed as a factorial with all rate combinations of mesotrione and atrazine included. The study also included a weed free plot. Each site received s-metolachlor at the recommended rate for each soil type. Weed control was evaluated visually and weed densities were determined 30, 45, and 60 DAT. Plots were harvested for corn yield determination.

Triazine-resistant common lambsquarters was easily controlled by mesotrione and was not controlled by atrazine at any rate tested. All rates of each herbicide controlled non-triazine resistant common lambsquarters greater than 90 percent. The highest three rates of mesotrione provided 89 percent or greater control of velvetleaf, regardless of atrazine rate. Control of common ragweed was 85 percent or greater from mesotrione at 158 g/ha in combination with atrazine at 560 g/ha or higher. In addition, mesotrione at 210 g/ha combined with atrazine at 280 g/ha or higher provided 91 percent or greater control of common ragweed. The only effective treatments for giant ragweed control were mesotrione at 210 g/ha in combination with atrazine at 1120 g/ha or higher.

EFFICACY AND DEGRADATION OF MESOTRIONE AND ISOXAFLUTOLE IN THE SOIL. Nicholas T. Fassler and F. W. Simmons, Graduate Research Assistant and Associate Professor, Department of Crop Science and Department of Natural Resources and Environmental Sciences, University of Illinois, Urbana, IL 61801.

Soil dissipation rates determine temporal efficacy relations for herbicides with soil activity. Little is known about the relative dissipation rates of two recently introduced herbicides; mesotrione and isoxaflutole. Our study had two objectives: 1) To determine if there is a significant difference in the length of control between preemergence (PRE) applications of isoxaflutole and mesotrione and 2) To explore the possibility of a soil pH interaction with herbicide degradation rates. Greenhouse bioassay experiments were conducted on field-sampled soils treated with isoxaflutole and mesotrione in 2002 and 2003 at three Illinois locations. Soil types at the three locations were Flanagan silt loam with 3.6% O.M., Drummer silt loam with 4.5% O.M., and Cisne silt loam with 2.1% O.M. These studies were conducted on established pH plots where the pH was adjusted to incremental levels ranging from < 6.0 to > 7.5. Mesotrione was applied PRE at 211 g ha^{-1}, 158 g ha^{-1}, and 105 g ha^{-1} while isoxaflutole rates were 105 g ha^{-1}, 78 g ha^{-1}, and 52 g ha^{-1}. Soil samples were taken from the middle of each plot 5 to 10 days after application and at every 14 days up to 40 days after application. Soil samples were returned to the greenhouse and planted with velvetleaf and common waterhemp as bioassay species. Soil samples were mixed and re-planted after successive 15-day grow out periods until no visible control was observed. Herbicide efficacy based on bioassay results was similar for both herbicides in most locations and years. Soil-dissipation rates based on decrease of velvetleaf control from 100 to 80% ranged from 11 to 52 days Growing degree-day indices better described dissipation rates than did a simple days after application variable.

DANDELION CONTROL WITH SPRING APPLIED, PRE-PLANT TREATMENTS IN NO-TILL CORN. J. Earl Creech, William G. Johnson, and Reece A. Dewell, Graduate Research Assistant, Assistant Professor, and Postdoctoral Research Associate, Purdue University, West Lafayette, IN 47907.

Dandelion management in no-till cropping systems has become a major concern for growers in Indiana and throughout the North Central region. Field studies were conducted at the Agronomy Center Research and Extension (ACRE), West Lafayette, IN, in 2003 to evaluate control of established dandelion in no-till corn with late spring applied treatments. In an initial experiment, combinations of a number of commonly used burndown and preemergence corn herbicides were applied on May 8. A second study was initiated on May 22 to examine the interaction between *s*-metolachlor + atrazine + mesotrione (Lumax) and paraquat. Treatments were arranged in a randomized complete block design with four replications. Visual estimates of dandelion control were taken at two-week intervals throughout the growing season. Treatments containing paraquat generally received higher ratings at 14 days after treatment (DAT) than treatments without. The *s*-metolachlor + atrazine + mesotrione treatment controlled dandelion 71% while the addition of paraquat increased control to 94% or greater. At 41 DAT, dandelion control with treatments containing paraquat had decreased to levels similar to treatment combinations without paraquat. Treatments containing glyphosate, *s*-metolachlor + atrazine + mesotrione, or 2,4-D generally provided greater than 80% dandelion control at 41 DAT. Mesotrione at 105 g/ha and 210 g/ha controlled dandelion 68% and 80%, respectively. The addition of atrazine to mesotrione had no effect on dandelion control in this study. Although initial (11 DAT) activity was approximately 4-fold higher than mesotrione alone, dandelion control in the mesotrione + paraquat treatments was 8-15% less than a similar rate of mesotrione alone at 35 DAT. These studies demonstrate that a number of herbicides can be effective for suppression of established dandelion in the spring.

CORN HYBRID AND HERBICIDE INTERACTION RESEARCH PLOT. H. Thomas Fick, General Manager K Double T Crop Consulting, 314 South 4th ST. Albion, NE. 68620.

Giltner, NE. has been the site of research for the interaction of a wide base of hybrid genetics with various herbicides for four years. This presentation will only provide information for 2002 and 2003. The research plot is pivot irrigated on a Hastings silt loam soil. The plot is replicated threes times and utilizes a seventy- five foot row length with fifteen treatments that includes a hand weeded and untreated check.were five row plots and 2003 were four row plots.

Herbicides used in the project include: mesotrione, carfentrazone-ethyl, rimsulfuron-nicosulfuron, foramsulfuron, dimethenamid-P, dimethenamid-P + atrazine, diflufenzopyr + dicamba, dicamba DGA salt, atrazine + metoachlor, isoxaflutole, mesotrione + metolachor + atrazine, flufenacet. An additional product tested was a harpin protein (Messenger) .

All products were studied for symptoms of injury and weed control. Various differences by hybrid are noted. All treatments are taken to yield and comparison then made and summarized. Individual data is sent to all cooperators involved in the research. Summary results will be shown for this presentation. Hybrids are all coded for confidentiality. Information on individual hybrids maybe obtained through K Double T Crop Consulting.

THE INFLUENCE OF APPLICATION TIMING ON CROP SAFETY OF POSTEMERGENCE CORN HERBICIDES. Thad Haes, Richard Smelser, Wayne Fithian, Kevin Barber, Nick Schnieder, Chad Kalaher, and Brent Tharp, Golden Harvest, Waterloo, NE 68069.

Research has been conducted since 1983 to determine herbicide tolerance of Golden Harvest brand hybrids to various postemergence herbicides. Trials have been conducted at 7 to 9 locations throughout the Corn Belt in a randomized complete block design (strip-plot arrangement) with three or four replications per location. Up to 24 herbicide treatments and/or herbicide treatment timings and up to 35 hybrids were evaluated at each site year. Herbicides were tested at their highest commonly used labeled rate and at two crop timings. Crop timings were 5 inch (V2 growth stage) and 12 inch (V5-V6 growth stage) crop height. Plots were maintained weed free to eliminate the effect of weed control efficacy differences among herbicides on crop yields. Weeds were controlled by treating the entire plot area with a chloroacetamide applied preemergence and by hand weeding if necessary. Grain moisture and yield were collected using a small-plot combine. Linear regression was used to evaluate overall crop safety differences of the two application timings across yield environments. The 5 inch timing mean was regressed against the 12 inch timing mean of each herbicide treatment. Treatment means represent the average yield of all hybrids tested in each individual site year at that timing.

Crop safety differences existed across modes of action, among products within a mode of action, and across yield environments when comparing yield of 5 inch application timing to 12 inch application timing. Yield of five inch applications were consistently higher for mesotrione (Callisto), clopyralid + flumetsulam (Hornet WDG), nicosulfuron + diflufenzopyr + dicamba (Celebrity Plus), and nicosulfuron + rimsulfuron + clopyralid + flumetsulam (Accent Gold WDG) when compared to 12 inch applications. For diflufenzopyr + dicamba (Distinct) and nicosulfuron + rimsulfuron + atrazine (Basis Gold), data indicated application timing influenced crop safety differently by yield environment. In highest yielding environments (above 180 bushels per acre), the 5 inch application timing was consistently greater in crop safety when compared to the 12 inch application timing. Distinct and Basis Gold showed good crop safety at both application timings in yield environments below 160 bushels per acre. In mid-level yield environments (160 to 180 bushels per acre), Distinct and Basis Gold showed increased variability compared to higher and lower yield environments, negating any potential influence of application timing on crop safety.

Application timing did not consistently influence crop safety for nicosulfuron + rimsulfuron (Steadfast), indicating that environment was the major factor influencing the performance of Steadfast, regardless of application timing and yield level. Study showed that no herbicide treatments were consistently higher yielding for the 12 inch application timing when compared to the 5 inch application timing.

2003 North Central Weed Science Proceedings 58:93.

DIFFERENCES IN HYBRID SENSITIVITY TO POSTEMERGENCE CORN HERBICIDES. Richard Smelser, Thad Haes, Wayne Fithian, Kevin Barber, Nick Schnieder, Chad Kalaher, and Brent Tharp, Golden Harvest, Waterloo, NE 68069.

Research has been conducted since 1983 to determine herbicide tolerance of Golden Harvest brand hybrids to various postemergence herbicides. Trials have been conducted at 7 to 9 locations throughout the Corn Belt in a randomized complete block design (strip-plot arrangement) with three or four replications per location. Up to 24 herbicide treatments and/or herbicide treatment timings and up to 35 hybrids were evaluated at each site year. Herbicides were tested at their highest commonly used labeled rate and at two crop timings. Crop timings were 5 inch (V2 growth stage) and 12 inch (V5-V6 growth stage) crop height. Plots were maintained weed free to eliminate the effect of weed control efficacy differences among herbicides on crop yields. Weeds were controlled by treating the entire plot area with a chloroacetamide applied preemergence and by hand weeding if necessary. Grain moisture and yield were collected using a small-plot combine.

Results clearly indicate that hybrids differ in their sensitivity to most postemergence herbicide programs. Environment also plays a role in herbicide safety and can be a dominant force influencing crop response in specific field situations. Study design and interpretation methodology at Golden Harvest ensure that only true herbicide by hybrid interactions, and not interactions with environment, are reported. The system of analysis developed at Golden Harvest employs LSDs to separate herbicide programs for each hybrid at each trial location into crop safety categories based on yield. Safety categories are then tallied for each herbicide/ hybrid combination over locations and years. Crop safety ratings for each herbicide/hybrid combination are assigned based on the distribution of responses across each safety category over years and locations. Crop safety ratings include a green star, blue circle, orange yield sign, and black “X,” which stand for low risk, standard risk, application management required, and not recommended, respectively.

Golden Harvest herbicide ratings are designed to help maximize yields by maintaining adequate weed control while optimizing crop safety. Producers are encouraged to first select the best hybrid for their field conditions, and then the best herbicide(s) based on predominate weed species. Herbicide ratings are then consulted for the selected hybrid and herbicide combination(s). Guidelines are provided for hybrid/herbicide combinations rated “application management required” to minimize potential yield loss associated with this crop safety category. Guidelines are driven by both Golden Harvest data and herbicide label recommendations and include crop timing, herbicide rate, adjuvant option, environmental condition “watch-outs,” and tank-mix partner considerations.

PHYTOTOXICITY AND YIELD OF FIVE POPCORN VARIETIES IN RESPONSE TO POST HERBICIDES. 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 in 2003 to determine the effect of three POST applied herbicides on crop injury and yield for five popcorn varieties. The experimental design was a split plot with three replications. Popcorn variety was the whole plot and herbicide was the split plot. Popcorn varieties included Crookham R-98114W, Iowa Acres A-3035, Zangger N-11649, Ag-Alumni, and Schlessman SH4862. Herbicides included mesotrione, dicamba plus diflufenzopyr, and foramsulfuron. Untreated controls were included and maintained weed free. Split plots were 3 by 7.6 m and experiments were planted with 76 cm row spacing on soybean ground prepared by spring field cultivation. All herbicides were applied at labeled rates appropriate for V2 to V4 dent corn. Percent visual crop injury was evaluated at 1, 2, 3 and 5 weeks after application (WAA). Percent stalk lodging was recorded two weeks prior to harvest. Plots were machine harvested and yield was corrected to 15.5% moisture.

Crop injury observed 1 and 2 WAA revealed significant variety by herbicide interactions. Injury resulting from mesotrione and dicamba plus diflufenzopyr varied significantly for different popcorn varieties at both observation dates. Foramsulfuron, conversely, demonstrated injury that was consistently near 20% at 1 WAA and between 15 and 20% at 2 WAA. Mesotrione and foramsulfuron demonstrated the highest injury across varieties at 1 WAA. Mesotrione injury at 1 WAA ranged from 17 to 28% and was characterized by chlorotic upper leaves. Foramsulfuron and dicamba plus diflufenzopyr injury ranged from 18 to 22% and 8 to 18%, respectively, at 1 WAA. Injury from both herbicides appeared as shortening of upper internodes and chlorosis. Mesotrione injury was greatly reduced from one to two WAA, while foramsulfuron and dicamba plus diflufenzopyr injury was more persistent. Injury across varieties was highest with foramsulfuron at 2 WAA, followed by dicamba plus diflufenzopyr and mesotrione.

There was no significant variety by herbicide interaction for injury observations 3 and 5 WAA. At 3 WAA, foramsulfuron again demonstrated the highest injury across varieties. Dicamba plus diflufenzopyr and mesotrione were similar for injury severity. There were no differences in injury between herbicide treatments at five WAA.

No variety and herbicide interaction was detected for stalk lodging. There were significant variety and herbicide differences. Dicamba plus diflufenzopyr, caused more lodging than foramsulfuron when averaged across varieties. However, no herbicide treatment had significantly more lodging than the untreated control. Lodging differences between treatments were more often a variety effect. Crookham R-98114W lodging was higher than Iowa Acres popcorn variety. However, there were no other significant differences in lodging between varieties.

Zangger N-11649 was the highest yielding variety. However, there were no other significant differences or variety and herbicide interactions. Herbicide injury did not affect popcorn yield.

Managing Early Season Weed Competition In Corn-Residual vs. Total Post Weed Control Programs. Adrian J. Moses, Terence M. Carmody and Michael D. Johnson, Research and Development Scientist, Research and Development Scientist and Technical Brand Manager, Syngenta Crop Protection, Greensboro, NC 27419

LUMAX™ is a mixture of mesotrione, *S*-metolachlor, and atrazine that was introduced in 2003 by Syngenta Crop Protection. Mesotrione applied pre-emergence provides excellent control of the most important broadleaf weeds in corn including velvetleaf, pigweed species, waterhemp species, common lambsquarters, jimsonweed, nightshade species, and Pennsylvania smartweed. The addition of *S*-metolachlor and a low rate of atrazine to mesotrione in this pre-packaged mix resulted in broad spectrum and consistent control of both annual grass and broadleaf weeds. LUMAX was compared to glyphosate applied post-emergence as a single application or as two applications and at various application timings. No crop injury was observed from LUMAX at any location. Weed control and yields will be reported across multiple US locations.

MEASUREMENT OF GLYPHOSATE RESISTANCE IN WATERHEMP. David A. Smith and Steven G. Hallett, Graduate Research Assistant and Associate Professor of Weed Science, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Waterhemp, *Amaranthus tuberculatus* Sauer., has become a key weed in the Midwestern US in the last 10-15 years. One of the reasons for the ascendance of waterhemp has been the development of biotypes of the weed resistant to s-triazine, diphenylether, ALS-inhibitor, and protox-inhibitor chemistries, and recently growers have expressed concern that biotypes of the weed have developed resistance to glyphosate. We received samples of seed from putative glyphosate resistant populations in Illinois, Missouri, and Iowa in order to test the levels of tolerance of waterhemp from different parts of the Midwest. Investigating glyphosate resistance in waterhemp presents a significant challenge, since the plant exhibits extreme genetic variability, and is dioecious. To overcome these difficulties, we chose to follow a screening process followed by glyphosate rate testing on clonally-propagated populations from selected plants. Seed from these putative resistant populations were sown in large flats, grown to the 4-6 leaf stage and then challenged with glyphosate (foliar spray, 0.63 kg ae ha^{-1} at 186 L ha^{-1}). In the case of the Illinois and Missouri populations approximately 10% of the plants survived. All the plants from the Iowa population were killed, and therefore not used further in this experiment. Of the surviving plants, selected individuals were transferred to individual pots and propagated. As a control, we used a population of waterhemp from Fowler, IN which was not pre-screened prior to the selection of parent clonal populations. Shoot apices were cut just below axillary buds, dipped in rooting hormone, planted into fresh potting soil and maintained in a humid environment under a plastic cover for 7 d. In this way 54 clones of each selected parent was generated. Clones were challenged with glyphosate at 1/8X, 1/4X, 1/2X, 1X, 2X, 4X, 8X, and 16X rates (X = 0.63 kg ae ha^{-1}). In order to control for the effect of changing formulation concentrations, we used a fixed concentration of the formulation blank of GlyphomaxPlus® mixed with various concentrations of the technical grade isopropylamine salt of glyphosate. Clonal populations of waterhemp from different parents had different responses to glyphosate. Although GR50 values were similar for all clones, GR90 values were considerably different. Clone 1 (Altamont, IL) and Clone 10 (Altamont, IL) had GR90 values 7.2 and 9.1 times greater than that of the susceptible control (Fowler, IN). The lethal dose to kill 50% or 90% was greater than 10.08 kg ae ha^{-1} for clone 1. Several clones had LD50 and LD90 values which were much higher than for clone 16 (susceptible control). These findings confirm that different populations of waterhemp in the Midwest respond very differently to glyphosate. Some individual waterhemp plants survived applications of glyphosate more than 16 times greater than the recommended rate for waterhemp control in the region. Plant survival at 1-4 times the recommended rate was common. Current glyphosate use rates are frequently delivering sub-optimal control of waterhemp, which may result in waterhemp escapes where glyphosate is used as the predominant weed management strategy. We hypothesize that this practice has caused selection for resistance to glyphosate in Midwestern waterhemp, and we predict that glyphosate resistance in waterhemp will continue to develop if management regimes do not change to reduce this selection pressure.

EVALUATION OF POTENTIAL WATER CONDITIONERS AS ADJUVANTS FOR GLYPHOSATE. Donald Penner and Jan Michael, Michigan State University, Department of Crop and Soil Sciences, East Lansing, MI 48824.

Anionic herbicides such as glyphosate readily form salts with cations occurring in hard water. These include Ca, Mg, and Fe. Water conditioning adjuvants such as diammonium sulfate are recommended to prevent the formation of the salts which are not as readily absorbed by plants. Relevant to the goal of identifying and evaluating potential water conditioning substitutes for diammonium sulfate we established that the requirement for a water conditioner differed with the weed species as follows: velvetleaf>giant foxtail>common lambsquarters. Furthermore, both the NH_4^+ and the SO_4^- contributed to the water conditioning efficacy of diammonium sulfate. The motivation for searching for potentially new water conditioning adjuvants is driven by the desire to find water conditioners that are liquid, have a high specific activity, and are cost effective. Studies conducted in the greenhouse have identified Exacto 390 and NTANK as potential water conditioners for glyphosate. They are liquid, have a high specific activity, are effective with a wide range of glyphosate products, and across a number of weed species.

ENHANCING HERBICIDE SELECTIVITY WITH WATER REPELLENTS. Eric A. Nelson and Donald Penner, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

A potential method of enhancing herbicide selectivity is the addition of water repellent adjuvant that would decrease injury to the crop by reducing foliar absorption while maintaining weed control. Potential situations for water repellent use include: application of soil active herbicides to turf so the spray solution is bounced through the thatch to the soil, application of herbicides that may cause excessive crop injury if foliar contact occurs such as a planned preemergence application to a partially emerged crop or a postemergence application of a herbicide that may cause crop injury. For a water repellent to be useful, the herbicide must have soil activity since the spray solution would be bounced off of weed foliage and crop foliage alike. The objectives of this research were to determine if adjuvants with water repellent properties could reduce herbicide retention on foliage and thereby absorption of the spray solution and to determine if herbicide efficacy was maintained with a reduction in foliar herbicide retention.

Water repellent adjuvants evaluated were DC 2-1322, DC 1-6184, and DC 772. These adjuvants were evaluated with three herbicides, isoxaflutole, pendimethalin, and flumioxazin, on three plant species. Two formulations of pendimethalin and isoxaflutole were evaluated. Pendimethalin formulations were EC and CS, while isoxaflutole formulations were SC and WDG. Flumioxazin was also formulated as a WDG. The commercially available silicone surfactant Sylgard 309 was evaluated as a positive control. Plant species evaluated were: 1) wheat, a hard to wet plant due to leaf orientation, 2) cabbage, a hard to wet plant due to a very waxy cuticle, and 3) tomato, an easier to wet plant. To evaluate spray retention, each treatment was applied with the dye Chicago Sky Blue. Spray retention was measured by washing the leaves after application and measuring the absorbance of the rinsate with a spectrophotometer at 625 nm. Herbicide efficacy was evaluated with the same treatments as above when soil contact was allowed on half of the plants and prevented on half of the plants. Thus, it was possible to isolate injury due to foliar as well as soil uptake of the herbicides.

Spray retention and plant injury were greatest on all species when Sylgard 309 was applied with all herbicides and formulations. Flumioxazin injury on cabbage only occurred when Sylgard 309 was included in the spray mixture. The water repellents, DC 2-1322 and DC 772 appeared ineffective with these herbicides and these plant species. DC 1-6184 effectively reduced spray retention for all three herbicides evaluated, regardless of formulation, on all three species. The EC formulation resulted in greater spray retention than the other formulations. The efficacy of DC 1-6184 was more evident if the spray application was restricted to the plant foliage. The adjuvant DC 1-6184 has potential to decrease injury while maintaining weed control with certain herbicides.

CHARACTERIZATION OF A WATERHEMP BIOTYPE WITH RESISTANCE TO PROTOPORPHYRINOGEN OXIDASE-INHIBITING HERBICIDES. William L. Patzoldt, Aaron G. Hager, Dean E. Riechers, Jonathan F. Holt, and Patrick J. Tranel, Graduate Research Assistant, Assistant Professor, Assistant Professor, Agricultural Research Specialist, and Associate Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Resistance to protoporphyrinogen oxidase (PPO)-inhibiting herbicides was identified in an Adams County, Illinois waterhemp population (ACR) during the summer of 2001. Field research conducted during the summer of 2002 suggested that normal field use rates of POST-applied PPO inhibitors did not control the ACR population; in contrast, PRE-applied PPO inhibitors did provide adequate control. These observations led to the hypothesis that expression of PPO inhibitor resistance might be developmentally regulated (i.e., growth stage dependent). Detailed herbicide dose-response experiments were initiated in the greenhouse with a PPO inhibitor-resistant waterhemp line derived from the ACR population, and compared with a known PPO inhibitor-susceptible waterhemp biotype from Wayne County, Illinois (WCS). Results from PRE-applied PPO inhibitor studies with lactofen or flumioxazin showed that the ACR biotype was less sensitive than the WCS biotype to these herbicides even when soil applied. However, the ACR biotype was adequately controlled when normal field use rates of either herbicide were applied PRE. Furthermore, results of dose-response experiments with POST-applied lactofen across different growth stages indicated that the level of resistance remained constant. Therefore, growth stage does not appear to influence the expression of resistance to PPO inhibitors in the ACR biotype. Results from inheritance experiments with F1 progeny of crosses between the ACR and WCS biotypes suggested that resistance is partially dominant, with F1 progeny intermediate in response to that of either parent. Research is being conducted to determine the mechanism of resistance to PPO inhibitors in the ACR waterhemp biotype.

CHARACTERIZATION OF THE MECHANISM OF GLYPHOSATE RESISTANCE IN HORSEWEED (*Conyza canadensis*). Greg Heck, R. Douglas Sammons, Paul Feng, Greg Bunkers, Minhtien Tran, Murtaza Alibhai, Youlin Qi, Stanislaw Flasinski, Marian Malven and Chris Hubmeier, Molecular Biologists and Physiologists – Agronomic Traits. Monsanto Company, 700 Chesterfield Parkway West, Chesterfield, Missouri 63017.

Conyza canadensis (horseweed, marestail, ERICA) is a winter or summer annual indigenous to North America that is readily dispersed and is now represented in both the New and Old World in a wide variety of agricultural systems. The appearance of glyphosate resistant horseweed in 2001 represented the first dicot species to be recognized as resistant to this herbicide. We have undertaken a series of studies to determine how this weed achieves resistance. We have previously established that a single dominant genetic locus accounts for biotypes with a glyphosate LD_{50} of 7-8X of the 1X use rate (0.84 kg ae ha^{-1}). We have also demonstrated that the mechanism is not due to metabolism of glyphosate.

Examination of the EPSPS genes of horseweed as candidates for the resistance locus has shown that three genes are present in the genome. Two of these genes (EPSPS1 and EPSPS2) are likely to be found in all members of the Asteraceae since we have cloned putative orthologs in close relatives such as annual fleabane (*Erigeron annuus*) and more distantly related willowleaf sunflower (*Helianthus salicifolius*). Horseweed EPSPS3 likely appeared in the genome after a gene duplication event of EPSPS2. Since that duplication, EPSPS3 has acquired a number of codon changes leading to several amino acid differences relative to EPSPS2. These changes, e.g. Q181V, disrupt catalytic activity and make EPSPS3 non-functional as demonstrated in biochemical assays, relegating EPSPS3 to psuedogene status. This observation, coupled with the lack of any functionally resistant EPSPS sequences, the absence of EPSPS gene amplification, and lack of increased EPSPS gene expression amongst the biotypes, eliminated EPSPS loci as causative agents for resistance in horseweed.

Although overall uptake is similar between susceptible and resistant biotypes, mechanistic work has focused on the observation of reduced glyphosate translocation in the resistant biotype. This characteristic is operational at the site of application and is manifest in reduced glyphosate translocation to crown and root. Work is ongoing to isolate the resistance locus.

We have surveyed geographically distinct biotypes and found reduced translocation was correlated with the resistance phenotype in the greenhouse and transmits genetically in crosses between susceptible and resistant biotypes. Reduced translocation, a lower shikimate:glyphosate ratio in the resistant biotype, and a sensitive target enzyme indicate a mechanism that functions to “shield” the EPSPS target from the full glyphosate dose normally experienced in a susceptible individual. The genetic relationship between the geographically distinct susceptible and resistant horseweed accessions analyzed in the greenhouse was examined by inter-MITE (Minature Inverted Transposable Elements) polymorphisms. Broad geographical and known genetic relationships were associated by this technique. Several distinct clades were evident in the data. At this point, we cannot determine if resistant populations potentially spread from a common source population or arose by independent origin in multiple populations. Cloning and sequencing of the resistance locus will be needed to resolve the origins of resistance in these populations.

MOLECULAR BIOLOGY AND GENOMICS: OVERVIEW AND APPPLICATIONS IN WEED SCIENCE. Gregory R. Heck, Senior Molecular Biologist. Monsanto Company, 700 Chesterfield Parkway West, Chesterfield, Missouri 63017.

Unprecedented advancements in tools to understand genes, phenotypes, biological systems and environmental interactions have emerged in recent years. Collectively massed under the heading of “Genomics”, these tools build on many technologies, some having their first appearance decades ago. The distinction for genomics is scale, breadth and throughput of current analyses. Rather than tracking the behavior of a single or small number of genes, entire gene networks can be assessed.

Large scale sequencing ushered in the era of genomics by providing complete organism sequences (genomes). The first finished genomes were bacterial. Although bacteria are far simpler organisms than higher plants, relevant genomes for the plant science community include photosynthetic cyanobacteria (e.g. *Synechocystis*), antecedents to the chloroplast. Both dicot (*Arabidopsis*) and monocot (rice) genomes are now accessible (www.ncbi.nlm.nih.gov/Genomes/index.html). Relatively small gaps in these genome sequences remain to be closed, but they are sufficiently complete to allow assessment of genome organization and the gene complement of higher plants. Other plant species have sequence information available in the form of Expressed Sequence Tags (ESTs) or cDNA representing segments of transcribed genes (www.ncbi.nlm.nih.gov/dbEST/dbEST_summary.html). For weed scientists, leveraging these reference genomes and EST collections can assist in gene discovery for weedy species that are unlikely to have their own genomic information. High homology has been shown to exist in closely related plant family members, enabling comparative genomics to determine the structure and orthology of genes. Approximately 80% of the *Arabidopsis* genes have recognizable homologs in rice, lending hope that weed species will be similar and that topics such as herbicide targets, resistance biology, and competitive characteristics can be studied in model species and their ecotypes.

Transcriptomics is the quantitative and qualitative comparison of the transcriptomes (the complete set of transcribed sequences in the genome at a given point in time). Synthesis of thousands of gene sequences on chips and hybridization with fluorescently labeled cDNA from comparative samples now permits the transcript profiling in response to developmental or environmental influences. Cascades of gene expression can be visualized and cohorts of gene expression changes monitored through time and can assist in response dissection. Current transcriptional profiling capability largely centers on the Arabidopsis and rice genomes. Use of these heterologous species chips for weed transcript profiling is possible, but limited due to the specificity of hybridization. Technologies that can rapidly synthesize chips from EST information or utilize emerging open platforms methodologies promise the ability of increased precision in weed transcript profiling.

Proteomics and metabolomics seek to compare the accumulated protein and small molecule profile of organisms, respectively. Since there can be a non-linear relationship extending from gene transcription to presence of an enzyme or its activity, these tools are important for a complete understanding of how genes interact to produce phenotype. Limitations include the ability to visualize all proteins by 2-D electrophoresis for proteomics and the difficulty in accommodating wide ranging chemical properties of a complete metabolite profile.

The role of a large number of genes remains to be determined. Functional genomics attempts to understand genes by creating collections of plants or microbes harboring evaluative libraries or mutant endogenous genes and screening them for altered phenotype. Insertional mutagenesis with transposons or transgenes (T-DNA) can “knock-out” (eliminate) function or be designed to activate gene expression through the use transformed enhancers and promoters. In limited situations, primarily cyanobacteria (*Synechocystis*) and the moss model systems (e.g. *Physcomitrella*), “knock-ins” are also possible where homologous recombination can be used to replace an endogenous sequence with a targeted mutation – applicable where a gene orthologous to a higher plant gene exists.

ARABIDOPSIS IS A WEED?: HETEROLOGOUS MICROARRAY USES IN WEED SCIENCE FOR NON-MODEL PLANTS. David P. Horvath, Research Plant Physiologist, USDA-ARS, Bioscience Research Lab, Red River Valley Agricultural Research Center, Fargo, ND, 58105.

Arabidopsis may not have weedy characteristics, but it certainly contains most of the same genes as weeds. Roughly 80% of the genes in Arabidopsis have recognizable counterparts in rice. Nearly half of these orthologous genes contain sufficiently long stretches of sequence similarity to allow gene probes from one species to hybridize to those of the other. Thus, it stands to reason that equivalent or greater number of genes would hybridize from species more closely related to Arabidopsis than rice. In addition to sequence conservation, there is substantial evidence that many signal transduction pathways regulating the expression of these similar genes are also well conserved. Interestingly, the most highly conserved genes are those involved in key steps in plant growth and development, photosynthesis, and stress responses. Consequently, the major differences in plant morphology and development are likely due to differences in expression or activity levels of a relatively small number of conserved regulatory genes.

We have taken advantage of these similarities to follow the expression of genes from leafy spurge and wild oats using Arabidopsis microarrays. We have also used tools developed for global expression analysis in Arabidopsis to infer information about the signal transduction pathways involved in growth and development of these two weeds. Our results have identified over 40 genes that are preferentially expressed in growing shoot apices of leafy spurge and seven that are preferentially expressed in the growing tiller of wild oat. Five of the seven genes preferentially expressed in wild oat tillers were also expressed in the growing shoots of leafy spurge. The expression of the putative orthologues of these genes in Arabidopsis suggest that several different regulatory pathways may be involved during growth and development of tillers and shoot apices in leafy spurge and Arabidopsis. There also appears to be some unexpected cross talk between cold-regulated and growth regulated signals transduction pathways.

Preliminary observations suggest that underground adventitious shoot buds of leafy spurge, often referred to as root buds in the literature, loose tight regulation of many growth responsive genes after three months of growth in the green house. Yet, the root buds of these plants do not develop into growing shoots unless the aerial portion of the plant is excised. These observations suggest an additional layer of growth regulation besides those of S-phase regulation previously shown to be imposed by the leaf derived signal. We have used Arabidopsis microarrays to identify 17 genes that are consistently preferentially expressed only in older dormant root buds, and one gene that is consistently preferentially expressed in the same buds upon growth induction. The results of these experiments will be discussed, although preliminary analysis appears to indicate that many of these genes are also responsive to light and oxidative stress.

HIGH-THROUGHPUT SCREENING STRATEGIES FOR NOVEL HERBICIDE TARGETS. Cory A. Christensen, Adel M. Zayed, Lining Guo, Kurt Boudonck, Todd M. DeZwaan, Rao V. Mulpuri, Vereesh L. Sevala, and Keith R. Davis, Research Scientist, Staff Scientist, Director of Biochemistry, Research Scientist, Research Scientist, Senior Research Scientist, Staff Scientist, and Vice President of Agricultural Research, Paradigm Genetics, Inc., Research Triangle Park, NC 27709.

We have developed a high-throughput screen for novel herbicide targets. The objective of this screen is to identify essential plant enzymes that can serve as targets in high-throughput screens for chemical compounds with herbicidal activity. To identify herbicide target genes we use the weed *Arabidopsis thaliana*. Essential *A. thaliana* genes are identified by screening for lethal phenotypes in lines where the target gene has been inactivated by anti-sense RNA expression. We use two methods of transgene expression, direct expression and transactivation. In the direct expression system, the anti-sense message is driven by a constitutive promoter. We screen for lethal phenotypes in the T1 generation and analyze multiple independent transformation events per target gene. In the transactivation system, expression of the anti-sense message depends on the independent expression of a transcriptional activator, or driver, that binds to an activating sequence upstream from the transgene. In this screen, the target gene construct and driver are brought together by crossing a driver-containing line and a T1 generation target-containing line. We screen for lethal phenotypes among the F1 progeny from multiple transformation events per target gene.

Anti-sense inactivation of an essential *A. thaliana* gene results in a lethal phenotype that severely impacts the health or viability of the seedling. Lethal phenotypes include chlorosis, necrosis, reduced plant size, and severe developmental abnormalities. If one or more of these phenotypes are seen in multiple individuals from independent transformation events, the target gene is promoted for assay development.

The purpose of assay development is to generate a method for screening the target gene function that is sufficiently robust for high throughput or ultra-high throughput screening applications. A thorough literature review and functional analysis of the target gene sequence is performed to determine the most appropriate assay format. Assay formats that we routinely use to evaluate protein function include *in vitro* assays of enzymatic functions, substrate binding assays, and cell-based assays in which the target gene is expressed in a surrogate host.

Once an assay has been developed, the target gene activity is tested against a library of tens of thousands of chemical compounds to identify ones capable of inhibiting the reaction. Hits from this ultra-high throughput screening are further tested on plants for *in vivo* herbicidal activity. At this point, these chemical compounds constitute product leads in an herbicide discovery program.

ANALYZING GENE EXPRESSION AT THE PROTEIN LEVEL: USING PROTEOMICS TECHNIQUES TO INVESTIGATE HERBICIDE SAFENER MECHANISM OF ACTION. Dean E. Riechers and Qin Zhang, Assistant Professor and Graduate Research Assistant, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

New molecular techniques are currently available that allow researchers to analyze global effects of treatments (such as herbicides or herbicide safeners) on gene expression patterns and profiles in plants. Examples of such techniques that are used as tools for gene discovery are cDNA microarrays (for genomics and functional genomics) and two-dimensional electrophoresis coupled with mass spectrometry (proteomics). One advantage of using these techniques is that they allow researchers to observe changes in gene expression for entire subsets of genes or proteins that are expressed under the given experimental condition.

Proteomics techniques are currently being utilized in our laboratory to examine all of the proteins that are expressed in the coleoptile of *Triticum tauschii* (a diploid wheat species with the D genome) seedlings, with and without herbicide safener treatment. Proteins are extracted from isolated coleoptiles, analyzed on two-dimensional protein electrophoresis gels (resolved by isoelectric point in the first dimension, and molecular mass in the second dimension), and the identity of individual protein spots are determined by mass spectrometry of peptide fragments derived from protease-digested proteins in the gel. Mass fingerprints that are generated are used to search the GenBank database for matches with corresponding peptide fragment masses from proteins in the existing database (usually deduced protein sequences translated from gene sequences). In addition to mass spectral analysis of individual proteins from the gel, we have also performed two-dimensional immunoblots probed with two different glutathione *S*-transferase (GST) antisera. Results to date show that the majority of safener-induced proteins are either phi or tau class GSTs, which vary greatly in both isoelectric point (pI 5 to 7) and molecular mass (24 to 29 kDa). Other safener upregulated proteins have also been identified that are not GSTs, but may also be involved in the safener response/herbicide detoxification pathway in wheat coleoptiles. Mass spectrometry data and immunoblot analyses have also indicated that there may be significant amounts of post-translational modification of GST proteins occurring in response to safener treatment. Future studies in our laboratory will examine protein profiles generated from *Triticum tauschii* coleoptiles that have been treated with herbicide (dimethenamid) only, herbicide safener only, and the herbicide plus safener together. We anticipate that these experiments will help us to better understand the entire herbicide detoxification pathway in wheat, and its biochemical components.

For molecular studies aimed at determining the regulation of gene expression in response to a given treatment, the ability to detect post-translational modification of proteins is a distinct advantage of proteomics techniques. Conversely, decreased sensitivity (relative to mRNA profiling with microarrays), difficulty in extracting integral membrane proteins, and the inability to identify proteins of very low abundance with current detection methods might be considered disadvantages of proteomics techniques. These drawbacks will hopefully be addressed and resolved once improvements are made with current proteomic technologies.

GLYPHOSATE RESISTANT VOLUNTEER CORN CONTROL WITH GLYPHOSATE GRASS HERBICIDE COMBINATIONS. Brady F. Kappler, Robert F. Klein, Alex R. Martin, Frew W. Roeth, Gail A. Wicks. Extension Educator – Weed Science, Professor, Professor, and Professor, Department of Agronomy University of Nebraska, Lincoln, NE 68583-0915.

As the acres of glyphosate resistant corn increase so does the number of acres of "volunteer" roundup ready corn in the following years glyphosate resistant soybean crop. Obviously this presents a problem since the preferred herbicide of choice is glyphosate resistant soybeans is glyphosate. The best treatment for volunteer corn has typically been one of the ACCase inhibiting grass herbicides. Rather than make two applications across the field producers prefer to apply glyphosate and the grass herbicides together in the same tank. The additive typically used with Glyphosate would be non-ionic surfactant (NIS) while several of the grass herbicides recommend either NIS or Crop Oil Concentrate (COC)

A field study was conducted at 3 locations in Nebraska to evaluate the effect of different additives on the efficacy of glyphosate and grass herbicide on volunteer corn and other weeds. The study was conducted in planted glyphosate resistant corn with natural weed pressure at Clay Center, Lincoln, and North Platte. The treatments included glyphosate herbicides glyphosate potassium salt (Roundup WeatherMax) and glyphosate isopropyl amine salt (Glyphomax) at 0.84 kg ae/ha. The grass herbicides in the study were fluazifop+ fenoxaprop, and clethodim at all 3 locations, and sethoxydim was included at Clay Center and Lincoln. These were used at normal rates for 29 to 37 cm tall corn. The additives chosen were 0.25% v/v NIS and crop oil COC at 2.3 l /ha. The treatments included glyphosate - grass herbicide and additive combinations and glyphosate and grass herbicides separately with each additive. The study was evaluated for glyphosate resistant corn control and other weed control at 10-14 and 25-30 DAT.

At Clay Center there was no difference between brand of glyphosate when mixed with grass herbicides for control. Fusion with NIS with both glyphosate brand provided significantly lower volunteer glyphosate resistant corn control than the other products as did WeatherMax and sethoxydim with COC. All other treatments provided 90+% control of the corn regardless of glyphosate, grass herbicide or additive. In Lincoln all of the products performed similarly averaging almost 90% volunteer corn control with no significant differences. At North Platte clethodim provided significantly less weed control when NIS was used. There were no differences between glyphosate brands or any other glyphosate grass herbicide mixtures. All volunteer corn control was over 90%. At all three locations there was no loss of glyphosate activity with any of the mixtures and glyphosate weed control of other weeds was not reduced with the addition of COC.

As a whole few differences were seen between different glyphosate - grass herbicide - additive mixtures in this study. Whether a glyphosate needs additional surfactant or not does not appear to play a role when controlling volunteer corn. The addition of grass herbicide or COC also does not appear to impact the activity of glyphosate. At the same time the addition of glyphosate to the tank mixture does not seem to impact grass herbicides ability to control volunteer corn. Also while it may not always be significant volunteer corn control was typically higher when COC was the additive versus NIS. With no apparent side effects COC appears to be the recommended additive for glyphosate resistant volunteer corn control applications when tank mixed with glyphosate.

EFFECT OF NOZZLE TYPE ON GLYPHOSATE EFFICACY AND SPRAY PARTICLE DRIFT.
Jeff M. Stachler, Mark M. Loux, Erdal Ozkan, Clark S. Hutson, and Steve D. Ruhl, Weed Science Extension Program Specialist, Associate Professor, Professor, County Extension Agent, and Associate Professor, Ohio State University, Columbus, OH 43210.

A field-size study and a small-plot study were conducted near Tiffin and Chesterville, Ohio, respectively, in 2003, to determine the effect of nozzle type and drift control adjuvant on the effectiveness of glyphosate. Both studies were arranged as a randomized complete block with two factors, nozzle type (XR Teejet at 40 psi, Turbo Teejet at 40 psi, AI Teejet at 40 and 60 psi) and drift control adjuvant (0 and 2.5 gal/100 gal spray mixture of Corral AMS Liquid, a liquid ammonium sulfate plus a polyacrylamide drift control adjuvant).

Three replications were used in the field-size study. Plot size was 60 ft wide by 711 to 1212 ft long (length of field). Glyphosate (Roundup UltraMax) was applied at a rate of 1.0 lb ae/A. A commercial-sized Patriot sprayer delivered a spray volume of 15 gal/A for each treatment using a 0.3 gal/min nozzle size. Spray coverage at the canopy level was measured using 26 by 76 mm water-sensitive paper. GPS coordinates were used to mark at least two patches of each weed species evaluated per plot. Weed control was evaluated 28 DAT.

The small-plot study used four replications and a plot size of 10 ft wide by 40 ft long. Glyphosate (Roundup WeatherMax) was applied to each treatment at a rate of 0.75 lb ae/A. All treatments were applied with a hand-held sprayer using 0.2 gal/min nozzles and a spray volume of 15 gal/A. Weed control was evaluated 14 DAT.

In the field-size study, there was no significant interaction between nozzle type and drift control adjuvant, allowing comparison of main effects only. There was no difference in nozzle type or drift control adjuvant for Canada thistle and seedling dandelion. There was a difference between nozzles for control of yellow nutsedge, common ragweed, and Venice mallow at an alpha level of 0.05, and for common lambsquarters and velvetleaf at an alpha level of 0.1. The XR Teejet and AI Teejet at 40 psi provided 93 and 91 % control of yellow nutsedge control compared to the AI Teejet at 60 psi that provided 86 % control. The XR Teejet provided 81 and 77 % control of Venice mallow and velvetleaf, respectively compared to the AI Teejet at 40 and 60 psi that provided 74 and 70 % and 69 and 70 %, respectively. The XR Teejet and Turbo Teejet provided 91 and 93 % control of common ragweed, respectively, compared to the AI Teejet at 60 psi that provided 86 % control. The AI Teejet at 40 psi and the Turbo Teejet provided 94 and 94 % control of common lambsquarters, respectively, compared to the XR Teejet nozzle that showed 91 % control. Adding the drift control adjuvant did not affect common lambsquarters control, but reduced control of velvetleaf, Venice mallow, and yellow nutsedge at an alpha level of 0.05, and common ragweed at an alpha level of 0.1. The drift control adjuvant provided 59 % control of velvetleaf, 64 % control of Venice mallow, 66 % control of yellow nutsedge, and 89 % control of common ragweed compared to no drift control adjuvant that provided 85, 85, 73, and 92 % control respectively.

In the small-plot study, all treatments controlled at least 98% of the giant foxtail, giant ragweed, and common lambsquarters, and control was not affected by nozzle type or drift control adjuvant.

Mixed results were obtained between the two studies. Nozzle type and drift control adjuvant affected weed control with a large commercial sprayer, but not with a small plot sprayer. In these studies, use of a polyacrylamide drift control adjuvant in a commercial sprayer reduced the effectiveness of glyphosate. Glyphosate was more effective when applied with XR Teejet or Turbo Teejet nozzles, compared to AI Teejet nozzles when used in a commercial sprayer.

INFLUENCE OF GLYPHOSATE FORMULATION, PRODUCT RATE, AND CARRIER VOLUME ON SPRAY DRIFT. Bryan G. Young, Associate Professor, Southern Illinois University, Carbondale, IL 62901.

Herbicide applicators invest a significant amount of time and expense to minimize glyphosate spray drift. Current glyphosate applications involve the use of numerous glyphosate formulations and a range of herbicide application rates and carrier volumes. The influence these factors have on glyphosate drift has not been described to the same extent as other parameters such as low drift spray nozzles or drift control adjuvants. Thus, wind tunnel studies were conducted using an XR110015 nozzle at 276 kPa with a wind velocity of 4.5 m/s to determine the influence of glyphosate formulation, product rate, and carrier volume on glyphosate drift.

In the first study, particle spray drift from 12 glyphosate formulations ranged from 47 to 63% of the spray volume applied. Based on the amount of particle drift, treatments could be divided into two categories, glyphosate formulations that do and do not require additional surfactant. Spray solutions containing glyphosate formulations that required additional surfactant resulted in less movement of the spray solution out of the nozzle target area (drift) than water alone. In most instances, spray solutions that did not require additional surfactant resulted in more particle drift than water alone.

In the second study, glyphosate (Roundup Weathermax) was applied at four rates in combination with three carrier volumes. This treatment arrangement influenced the concentration of glyphosate and the formulated adjuvant system in the spray solution. The greatest amount of drift (70%) occurred at the highest concentration (high glyphosate rate; low carrier volume) and the least amount of drift (51%) occurred from the lowest concentration (low glyphosate rate; high carrier volume). Glyphosate drift varied by 16% depending on the product formulation and by 19% depending on the herbicide rate and carrier volume. Thus, these factors deserve some consideration when implementing methods to minimize drift.

EQUIPMENT FOR SPRAY PARTICLE SIZE ANALYZATION. Robert N. Klein and Jeffrey A. Golus, Professor and Research Technologist, University of Nebraska, North Platte, NE 69101.

Spray particle size affects both drift and efficacy of pesticides. Drift needs to be managed to acceptable levels as it may result in under or over application of chemicals and ineffective pest control. Drift may also cause losses and/or costly litigation if sensitive crops in adjacent fields are damaged and cause unintentional contamination of foodstuffs due to unacceptable pesticide residues. Drift may also contribute to pollution of air and water resources and may affect the health and safety of susceptible human and livestock populations. By obtaining maximum efficacy from the pesticide one may be able to reduce rates and/or improve performance.

A Symaptec Helos/KF particle analyzer is being used at the West Central Research and Extension Center in North Platte, NE to evaluate particle sizes of nozzle tips. The analyzer uses laser diffraction to determine particle size distribution. With the R6 lens, it is capable of detecting particle sizes in a range from 0.5 to 1750 microns. The system is comprised of: 5mw Helium-neon laser, adjustable measuring zone, multi element detector including an auto alignment system, high speed fiber optic data communication interface, and a computer with Windox 4 operating software for control and operation of the Helos central unit. The software also generates charts and graphs of selected measurements. The entire width of the spray plume is analyzed by moving the nozzle across the laser by means of a linear actuator. A 175 gallon tank is located outside the lab to dispose of the various mixtures used during the analyses. Droplet characteristics such as volume median diameter (VMD) and percent of volume 210 microns and less (particles most prone to drift) can be obtained. Particle size analysis will assist in interpreting plot data and correlating it with applications made by nozzles commonly used by farmers and commercial applicators.

SPRAY PARTICLE ANALYZATION OF NOZZLE TIPS WITH HERBICIDES AND ADJUVANTS. Robert N. Klein and Jeffrey A. Golus, Professor and Research Technologist, University of Nebraska, North Platte, NE 69101.

Most spray nozzle tips used in the application of pesticides produce a distribution of droplet sizes. Droplet size refers to the diameter of an individual spray droplet. The nozzle tip spray pattern is made of numerous spray droplets of varying sizes.

Spray nozzle classification by droplet spectrum in the US was developed and approved by the American Society of Agricultural Engineers (ASAE) in August of 1999. This standard, S-572, defines droplet spectrum categories for the classification of spray nozzles relative to specified reference fan nozzles discharging spray into static air so no stream of air enhances atomization. This provides a means for relative nozzle comparisons based only on droplet size. Other drift and application efficacy factors - droplet discharge trajectory, height, velocity, air bubble inclusion, droplet evaporation and impaction on target – are not addressed. The standard is based on spraying water through the reference nozzles and the nozzles to be classified. Spray liquid properties may affect droplet sizes and should be considered by the end user. Flow rate and operating pressure are specified for each reference nozzle, as droplet size spectra from pressure atomizers are affected by flow rate and pressure.

Particle size is affected by nozzle tip size and design, herbicide and adjuvants. The percent of the spray volume 210 microns (µm) and less is a useful statistic when comparing particle size distributions. Small droplets produce most spray particle drift. With the 11002XR nozzle tip at 15, 30, 45 and 60 psi, the 210 µm and less percentage is 30, 52, 62, and 72 respectively with water as the carrier. Adding 2% ammonium sulfate did not change the values. Adding a glyphosate at a rate of 0.75 lb ae/a at a carrier volume of 10 gpa increased the percentages 7 to 10%. Adding Adjuvant A decreases the volume of 210 µm and less by 26 to 53%. These percentages stayed nearly the same with Adjuvant A plus ammonium sulfate plus a glyphosate. This combination did affect the amount of small droplets when nozzle size was increased. With water only, the 11002XR nozzle at 15 psi produced 30% of the spray volume in 210 µm and less, while the 11008XR nozzle produced 11% under the same conditions. With Adjuvant A plus ammonium sulfate plus a glyphosate, the 11002XR at 15 psi produced 17% of the spray volume in 210 µm and less, while the larger 11008XR nozzle produced 28%.

Increasing the size of the air induction nozzle did not reduce the percentage of the spray volume 210 µm and less. With the 11002AI, 3% of the volume was of this droplet size, while the 11008AI produced 8%. These measurements were taken at 30 psi.

The previous comparisons were not based on replicated trials, but on single observations. Additional research with spray particle size and distribution is needed. The results will aid in managing drift and improving efficacy.

OPTIMIZING FORAMSULFURON ACTIVITY AND ABSORPTION IN GIANT FOXTAIL AND WOOLLY CUPGRASS WITH VARIOUS ADJUVANTS. 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, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Greenhouse and laboratory studies were conducted to examine foramsulfuron activity and foliar absorption in giant foxtail and woolly cupgrass with various adjuvants. Adjuvant selection was important for giant foxtail control. Foramsulfuron provided 90% or greater giant foxtail control with the addition of methylated seed oil (MSO) or MSO plus 28% urea ammonium nitrate (UAN). When a crop oil concentrate (COC) or non-ionic surfactant (NIS) was added to foramsulfuron, giant foxtail control was only 20%. However when 28% UAN was added with these adjuvants control was increased to 90 and 85%, respectively. Foramsulfuron absorption in giant foxtail was closely related to giant foxtail control. Foliar absorption of ^{14}C-foramsulfuron in giant foxtail ranged between 35 and 90%, 24 hours after treatment (HAT), depending on adjuvant selection. The rate of absorption was greatest when MSO plus 28% UAN was added to foramsulfuron and absorption was maximized 4 HAT. Foramsulfuron absorption in woolly cupgrass reached its maximum absorption levels 2 HAT with all adjuvant combinations. Even though the rate of foramsulfuron absorption was quicker in woolly cupgrass, absorption trends by adjuvants were similar to giant foxtail. However, woolly cupgrass control was less than 20% for all adjuvant combinations. Additional greenhouse studies were conducted to examine foramsulfuron control of woolly cupgrass and giant foxtail at three different herbicide rates at three different growth stages. There was no rate or growth combination that resulted in satisfactory levels of woolly cupgrass control. However, control of giant foxtail was greater than 90% for all three rates of foramsulfuron at the 5 cm growth stage. Foramsulfuron applied at 74 g ha^{-1} (twice the field use rate) provided 58% control of 5 cm woolly cupgrass.

TIMING OF ISOXAFLUTOLE BURNDOWN TREATMENTS IN FIELD CORN. George S. Simkins*, Brent Philbrooke and Matthew Mahoney. Technical Service Representative, Product Development Manager and Product Development Representative. Bayer CropScience. Research Triangle Park, NC. 27709

Field trials were conducted at 10 locations to evaluate the burndown activity of isoxaflutole (79 g/ha) with crop oil concentrate (1% v/v) alone, or in tankmix combinations with atrazine (1120 g/ha) or 2,4-D ester (560 g/ha). Applications were made at three different timings: soon after weed emergence, approximately 10 and 20 days after weed emergence. Weed control was evaluated approximately 10 and 25 days after application for following weed species: giant foxtail, yellow foxtail, fall panicum, common lambsquarter, redroot pigweed, common waterhemp, velvetleaf, wild mustard, giant ragweed, common ragweed, common chickweed, hoary cress, rough fleabane, shepherd's purse, purple deadnettle, white cockle, henbit and common dandelion. Early applications (~1 leaf) to annual grasses (foxtails and fall panicum) provided the most effective burndown of these species. The addition of atrazine to the isoxaflutole treatment improved control and speed of burndown. Isoxaflutole with crop oil concentration alone or in combinations resulted in quick and complete control of common lambsquarter, redroot pigweed, common waterhemp, velvetleaf and common ragweed, irregardless of the weed size. Burndown of wild mustard was slow with isoxaflutole and crop oil concentrate alone. Isoxaflutole combinations on small (<23 cm.) mustard resulted in faster burndown. All treatments ultimately provided good control of small mustard. Giant ragweed burndown was slow, though the speed of burndown was improved by the atrazine combination. Giant ragweed at the four leaf stage was effectively controlled by isoxaflutole in combination with crop oil concentrate and atrazine or 2,4-D ester. Control of larger giant ragweed was inconsistent. Burndown of common chickweed, rough fleabane, purple deadnettle and hoary cress was generally slow. Combinations of isoxaflutole and crop oil concentrate with atrazine or 2,4-D provided effective control, of these weeds in less than 31 days, no matter how large the weeds were when treated. All sizes of shepherd's purse and white cockle were effectively controlled by all isoxaflutole treatments. Burndown of henbit and common dandelion was most effective when treatments were applied to larger weed sizes. Control of both of these weeds varied from fair to excellent, depending on the location. Combinations containing 2,4-D ester were most effective in controlling dandelion.

EVOLVING PROGRAMS TO CONTROL WEED ESCAPES IN GLYPHOSATE RESISTANT CORN. Jeremy Frie, Dennis Belcher, and Duane P. Rathmann, Technical Service Representatives, BASF Corporation, Research Triangle Park, NC, 27709.

Increasing glyphosate resistant corn acres are commonly planted in rotation with glyphosate resistant soybean causing continuous use of glyphosate, many times as a stand alone product. Repeated use of glyphosate has given rise to common weed escapes such as waterhemp, velvetleaf, common lambsquarters, kochia, Canada thistle, Pennsylvania smartweed, wild buckwheat, giant ragweed, dandelion, and volunteer alfalfa. Trials were conducted at six university sites in North Dakota, South Dakota, Minnesota, and Missouri to evaluate programs that would successfully control common weed escapes being experienced in glyphosate resistant corn. Glyphosate programs were enhanced with soil-applied applications of dimethenamid-P or dimethenamid-P plus atrazine, as well as post glyphosate applications tank mixed with dicamba, dicamba plus diflufenzopyr, dimethenamid-P, or dimethenamid-P plus atrazine. These additional modes of actions were successful in controlling the weed escapes common to glyphosate alone programs. At Lamberton, MN, corn yields were increased from 143 bushels per acre with glyphosate alone to 163 bushels per acre when glyphosate was tank mixed with dicamba plus diflufenzopyr.

A NEW MESOTRIONE, S-METOLACHLOR, and ATRAZINE PREMIX FOR THE CENTRAL AND SOUTHERN CORN BELTS. Tom B. Threewitt, Charlie F. Grymes, and Michael D. Johnson, R&D Scientist, R&D Scientist and Technical Brand Manager, Syngenta Crop Protection, Greensboro, NC 27419.

Thirty Five field trials were conducted in 18 states in 2003 to evaluate A14155, a new premix in corn, for weed control and crop safety. Treatments were applied preemergence to field corn in replicated field trials in the states of AL, AR, FL, GA, IL, IN, KS, LA, MD, MO, MS, NC, NE, NY, OH, OK, TN and TX. A14155 is a new premix of mesotrione + S-metolachlor + atrazine at a unique ratio of 1:7.75:7.75. A14155 was evaluated on 39 weeds common to the central and southern corn belt. A14155 at 188+1458+1458 g ai/ha (3104g ai/ha in total) gave better control of Texas panicum, pitted morningglory, red morningglory, entireleaf morningglory, large crabgrass, yellow nutsedge, triazine resistant lambsquarter, sicklepod, broadleaf signalgrass, common ragweed and henbit than 1425 + 1813 g ai/ha of S-metolachlor + atrazine (or Bicep II MAGNUM at 3238 g ai/ha). A14155 and Bicep II MAGNUM gave equal control of palmer amaranth, redroot pigweed, smooth pigweed, common waterhemp, common lambsquarter, Florida beggarweed, southern crabgrass, barnyardgrass, common sunflower, marestail, kochia, ballonvine, fall panicum, Pennsylvania smartweed, wild radish, giant foxtail, yellow foxtail, green foxtail, prickly sida, johnsongrass, Florida pusley, giant ragweed, velvetleaf and cocklebur. A14155 provided crop safety equal to that from Bicep II MAGNUM. The tank mix of mesotrione + S-metolachlor + atrazine at 188+1458+1458 g ai/ha was equal to the premix formulation of these herbicides at the same combined rate of 3104 g ai/ha. Proposed rates of the new premix for a medium soil was determined to be 188+1458+1458 g ai/ha (3104g ai/ha) and for a fine soil to be 220+1705+1705 g ai/ha (3630g ai/ha).

EFFECT OF ADJUVANTS AND APPLICATION TIMING ON THE EFFICACY OF POSTEMERGENCE APPLICATIONS OF NICOSULFURON PLUS RIMSULFURON AND MESOTRIONE MIXTURES IN CORN, Susan K. Rick, Larry H. Hageman, Kevin L. Hahn and David W. Saunders, Development Representatives and Product Development Manager, DuPont Ag & Nutrition, Johnston, IA 50131.

Field studies were conducted in corn to determine the effect of application timing and the effect of various adjuvant systems on the control of large crabgrass, green foxtail, yellow foxtail, giant foxtail, and various broadleaf weed species with Steadfast (nicosulfuron + rimsulfuron) plus Callisto (mesotrione) and atrazine tank mixtures. Timing of application at two growth stages, within the labeled corn heights, showed little difference in efficacy on grass and most broadleaf weed species or on crop response. In additional trials, at above maximum weed heights, it was found that use of a MSO/OS adjuvant provided the greatest control of grass weeds when used in combination with Steadfast and the tank mix partners. Crop response in these trials was similar across all adjuvant systems with all treatments.

EFFECTIVENESS OF MESOTRIONE FOR WEED CONTROL IN GRAIN SORGHUM. Curtis R. Thompson, Mark M. Claassen, Larry D. Maddux, David L. Regehr, Alan J. Schlegel, John Frihauf and, Phillip W. Stahlman, Associate Professor, Professor, Professor, Professor, Professor, Research Scientist, and Professor, Kansas State University Southwest Research Extension Center, Garden City, KS, 67846, Kansas State University Harvey County Experiment Field, Hesston, KS 67062, Kansas State University KS River Valley Experiment Field, Topeka, KS 66618, Kansas State University, Agronomy Dept. Manhattan, KS 66506, Kansas State University Southwest Research Extension Center, Tribune, KS 67879, Kansas State University Agric. Research Station, Hays, KS 67601 and Kansas State University Agric. Research Station, Hays, KS 67601.

Weed control in grain sorghum continues to be a challenge because of the limited number of herbicide products available to growers. Field experiments were conducted near Hays, Hesston, Manhattan, Powhattan, and Tribune, KS in 2003, to evaluate two prepackaged mixtures mesotrione&S-metolachlor (1:10 ratio) and mesotrione&S-metolachlor&atrazine (1:10:3.7 ratio) were compared to prepackage mixes of S-metolachor&atrazine (1.247:1 or 0.774:1 ratio) for grain sorghum tolerance and weed control. All herbicides were soil surface applied at one (1X) and two (2X) times the field use rates 20 days before planting (20 DBP), 10 days before planting (10 DBP), and preemergence (PRE) immediately following planting. Use rates were mesotrione&S-metolachlor 2.06 kg/ha, mesotrione&S-metolachlor&atrazine 2.76 kg/ha, S-metolachlor&atrazine (1.247:1 ratio) 2.52 kg/ha or (0.774:1 ratio) 3.24 kg/ha. Mesotrione&S-metolachlor&atrazine at the 2X rate applied PRE injured sorghum 3% at Tribune 3% and 8% at Powhattan. Mesotrione&S-metolachlor at the 2X rate applied PRE injured sorghum 5% 2 WAT at Powhattan. No other treatments visibly injured sorghum at any location. Sorghum injury at Powhattan may have been confounded with a soybean herbicide, sulfentrazone carry over. Sorghum injury at Tribune was confounded with iron chlorosis. It appears that grain sorghum has adequate tolerance to soil applied mesotrione&S-metolachlor and mesotrione&S-metolachlor&atrazine. Grain sorghum yields were similar among treatments at 3 of the 5 locations. Grain sorghum yields were highest with PRE treatments compared to treatments applied 10 and 20DBP and tended to be higher with the 2X rates compared to the 1X rates at Tribune and Hays.

All treatments at one or more locations controlled green foxtail, large crabgrass, carpetweed, redroot pigweed, tumble pigweed, kochia, and Russian thistle. Puncturevine controlled 95% or better at all locations except Tribune, where control was 80% or better with the 2X rates applied PRE providing the most control.

These results indicate that grain sorghum has adequate tolerance to soil applied Mesotrione&S-metolachlor and mesotrione&S-metolachlor&atrazine and that these herbicides could offer effective weed control in grain sorghum. However, these herbicides are not registered for use in grain sorghum at this time.

COMPARISON OF ONE-PASS WEED CONTROL PROGRAMS FOR THE NORTHERN AND CENTRAL CORN BELT. Michael J. Urwiler, Brett R. Miller and Michael D. Johnson, Research and Development Scientists and Technical Manager, Syngenta Crop Protection, Greensboro, NC 27419.

The pre-package mixture of mesotrione (2-[4-methylsulfonyl-2-nitrobenzoyl]-1,3-cyclohexanedione), *S*-metolachlor and atrazine (trade name LUMAX^{TM}) was introduced commercially in 2003 by Syngenta Crop Protection for pre-emergence one-pass control of many troublesome grass and broadleaf weeds in field corn. In 38 field trials designed for the Northern and Central Corn-belt, LUMAX was directly compared to other one-pass weed control programs. LUMAX was applied pre-emergence at rates of 2670 to 3300 gai/Ha with the specific rate dependent on soil organic matter. LUMAX was tested alone in areas that limit atrazine rates and with an additional 1120 g ai/ha atrazine in areas that allow for higher atrazine use rates. The results show that several programs, including LUMAX and LUMAX plus atrazine, can be successfully utilized as a one-pass pre-emergence solution for many corn acres in the Northern and Central Corn-belt.

COMPARISON OF THE BEST TWO-PASS WEED CONTROL OPTIONS IN CORN. David A. Thomas, Michael J. Urwiler , Brett R. Miller and Michael D. Johnson, Research and Development Scientists and Technical Manager, Syngenta Crop Protection, Greensboro, NC 27419.

Many weed control option exist for the control of grass and broadleaf weeds in field corn. One very effective option for the control of weeds in difficult sites is a planned two-pass herbicide program, i.e. pre-emergence application followed by a post-emergence application. In 2001, mesotrione (2-[4-methylsulfonyl-2-nitrobenzoyl]-1,3-cyclohexanedione) was introduced as Callisto™ by Syngenta Crop Protection and has proven to be an effective post-emergence product for the control of many troublesome broadleaf weeds in corn. The objective of this study was to utilize mesotrione in a planned two-pass weed control program and compare this program to other two-pass weed control programs. The mesotrione based programs included the use of *S*-metolachlor or *S*-metolachlor plus atrazine applied pre-emergence followed by mesotrione plus atrazine applied post-emergence. The rates of the pre-emergence herbicides were adjusted depending upon the allowable atrazine use rate for a particular site and by soil type. The results from 30 University studies from across the US corn growing regions indicate that a planned two-pass weed control program utilizing mesotrione is very effective for the control of troublesome grass and broadleaf weeds and compares very favorably against other two-pass programs available in corn.

DICOT WEED CONTROL IN COOL-SEASON GRASS PASTURES. William W. Witt, Professor, Department of Agronomy, University of Kentucky, Lexington KY 40546.

There is an estimated six million acres of cool-season grass pastures in Kentucky utilized as forage for beef, dairy, and equine production. Annual, biennial, or perennial dicot weeds infest essentially all of the acreage. Weed control in beef and dairy pastures is complicated by the desire of growers to maintain existing stands of either red or white clovers. Field research was conducted in cool-season grass pastures to evaluate various herbicide combinations for control of weeds that commonly infest these pastures.

Herbicides evaluated were 2,4-D (dimethylamine salt), dicamba (Clarity), dicamba+diflufenzopyr (Overdrive), triclopyr+clopyralid (Redeem R&P), triclopyr+2,4-D (Crossbow), triclopyr+fluoxypyr), picloram+2,4-D (Grazon P+D), picloram+fluoxypyr (Surmount), clopyralid (Stinger), metsulfuron-methyl (Cimarron), and chlorsulfuron (Telar). All treatments were applied in water at 15 gpa utilizing flat fan nozzle tips at 40 psi. Plot sizes varied from 10 feet by 30 feet to 10 feet by 50 feet and there were at least three replications.

A study initiated in May 2002 compared the control of common dandelion and chicory in a tall fescue and orchardgrass pasture with Redeem R&P, Grazon P+D, Pasturegard, and Surmount applied either in late May, early July, and early September. Common dandelion control 8 WAT was greater than 80% for the following treatments: Redeem R&P at 2 or 3 pt/A; Grazon P+D at 2 or 3 pt/A; Pasturegard at 2 pt/A, and Surmount at 2 pt/A. Chicory control 8 WAT was greater than 90% for Redeem R&P at 2 or 3 pt/A and Grazon P+D at 2 or 3 pt/A while chicory control was between 70 and 75% for Pasturegard at 2 pt/A and Surmount at 2 pt/A. Chicory control 10 MAT was greater than 85% for Redeem R&P at 2 or 3 pt/A and Grazon P+D at 2 or 3 pt/A while control provided by Pasturegard and Surmount ranged between 63% and 73%. Redeem R&P, Grazon P+D, Pasturegard, and Surmount killed over 90% of red clover in the plots at the time of treatment. No injury to tall fescue or orchardgrass from any treatment.

Another study in 2002 evaluated curly dock control in a timothy hayfield. Treatments were made July 2 and evaluated 12 WAT. The greatest curly dock control was provided by Cimarron at 0.2 oz/A (90%), Redeem R&P at 3 pt/A (87%), and Weedmaster at 3 pt/A (83%). Curly dock control from 2,4-D amine was 50%.

Bulbous buttercup control was evaluated in a tall fescue pasture in 2003. Treatments were applied in April 2003 to bulbous buttercup plants about 12 inches in height. Bulbous buttercup control 8 WAT was 100% for the following treatments: Grazon P+D at 1.5, 2.0, and 2.5 pt/A; 2,4-D ester at 2 and 4 pt/A; Weedmaster at 2 and 3 pt/A; Cimarron at 0.2 oz/A; and Crossbow at 2 and 3 qt/A. Redeem R&P at the following rates provided the indicated control: 3 pt/A—80%; 2 pt/A—70%; 1 pt/A—50%.

In two studies in September 2003, tolerance of red clover to the above listed herbicides was evaluated. All herbicides killed greater than 60% of the red clover 4 WAT. These data indicated that excellent control of many troublesome weeds but red clover populations will be reduced severely, if not eliminated.

COMMERCIAL FIELD COMPARISONS USING IMAZAMOX TO ESTABLISH AND IMPROVE ALFALFA (*Medicago sativa*) STANDS. Ken Deibert, Duane Rathmann, Dennis Belcher, Mark Storr, and Paul Vassalotti, Technical Service Representatives, BASF Corporation, Research Triangle Park, NC 27709.

Alfalfa is the most commonly used forage for livestock feed in the United States. Currently, there are more than 23 million acres grown across the country to satisfy the demand for this high-energy forage. Imazamox herbicide is registered for use in seedling and established alfalfa for control of many economically important grass and broadleaf weeds. Research plots and field demonstrations were established across the Midwest to provide comparisons of alfalfa quality between imazamox herbicide treated alfalfa and untreated alfalfa. The objectives of this research were to demonstrate the effectiveness of imazamox to control important weeds in alfalfa production; compare relative feed value and crude protein between imazamox treated alfalfa and untreated alfalfa; and to evaluate the impact of forage quality on market value of alfalfa hay. Imazamox directly influenced the market value of alfalfa by increasing the quality of the hay. Conclusions were made to reflect that weed control is an essential component of alfalfa production in the interest of increasing overall forage quality.

QUACKGRASS CONVERSION TO NATIVE WARM SEASON GRASSES. Thomas G. Barnes and Brian Washburn, Extension Professor and Graduate Research Assistant, Department of Forestry, University of Kentucky, Lexington, KY 40546-0073

We implemented field research near Elkhart, IN during the spring 2001 to determine the efficacy of converting quackgrass (Elytrigia repens (L.) Nevski) to native warm season grasses (NWSG). The randomized-block experiment was designed to evaluate which herbicides would effectively kill quackgrass and the amount of imazapic herbicide required for residual weed control for the successful establishment of NWSG. The following treatments were applied in 0.1 ha treatment plots: Glyphosate at 2.2 kg ai/ha; Clethodim at 0.2 kg ai/ha; Imazapic at 0.06, 0.1, 1.6 kg ai/ha; Glyphostate at 2.2 kg ai/ha plus 0.03, 0.06, and 0.1 kg ai/ha and a non-treated control. A methylated seed oil surfactant at 2.3L/ha and 28-0-0 liquid fertilizer were including with all herbicides following manufacturer's recommendations. All herbicides were sprayed with a Demco™ spray unit delivering a spray volume of 187 L.ha at 414 kPa through Tee-Jet 8003 flat fan nozzles attached to an all-terrain vehicle driven at a constant speed of 2 - 3 kph. We planted a NWSG mixture at a rate of 6.9 kg pure live seed in the plots using a truax no-till drill. The seed mixture contained equal amounts of little bluestem (*Schizachryrium scoparium*), big bluestem (*Andropogon gerardii*), and indiangrass (*Sorghastrum nutans*). The control plots averaged 96 to 99% total vegetative cover and the quackgrass component increased from 84.7 to 90% during the two year study. There was an average of 2.7% NWSG in the plots that had an average of 2.7 plant species per plot. Bare ground increased from 9 to 12% by the end of the second growing season. The percent quackgrass in the Clethodim plots was reduced to 61.8% by the end of the second growing season and the NWSG increased from 10 to 17%. While this treatment did not effectively control the quackgrass, it did inhibit further growth during the initial growing season and prevented seed heads from forming. The plots treated with various rates of imazapic responded similar to the Clethodim treated plots in that the percent quackgrass was slightly reduced by the end of the second growing season to 80%, 70.5%, and 68.3% in the 0.06, 0.1, and 1.6 kg ai/ha treatments respectively. These treatments did inhibit further growth during the initial growing season and prevented seed heads from forming. The percent NWSG in these plots increased to 12%, 5%, and 23% in the 0.06, 0.1, and 1.6 kg ai/ha treatment plots respectively. The Glyphosate plots treated at 2.2 kg ai/ha provided the best control of quackgrass reducing the percent cover to approximately 12% at the end of the second growing season. The percent cover by NWSG in this treatment increased from 11 to 25% by the end of the second growing season. The plots where glyphosate was used to burn down the quackgrass followed by the application of imazapic at seeding NWSG showed great promise as the percent quackgrass was reduced to 14.9%, 10%, and 14.9% by the end of the first growing season in the 0.03, 0.06, and 0.1 kg ai/ha Imazapic plots. The increase in the percent quackgrass increased slightly during the second year to 16,8%, 21.2%, and 18% in the 0.03, 0.06, and 0.1 kg ai/ha plots respectively. These plots showed the greatest promise for establishing the NWSG as percent cover by these grasses at the end of the first growing season was 21%, 25,9% and 39.2% respectively. At the end of the second growing season the precent NWSG increased in all the plots where imazapic was used for weed control to 44.4%, 61.1%, and 57.2%. The results of this study confirm that the successful establishment of NWSG requires a good kill of the existing vegetation and that Imazapic aids in a quicker establishment.

USE OF HERBICIDES TO RESTORE NATIVE GRASSLANDS. Thomas G. Barnes and Marvin Ruffner, Extension Professor and Graduate Research Assistant, Department of Forestry, University of Kentucky, Lexington, KY 40546-0073

We implemented two field research studies throughout Kentucky during the spring 2001 and 2003 to determine the efficacy of using herbicides to remove tall fescue (*Festuca arundinacea*) from native grasslands dominated by indiangrass (*Sorgastrum nutans*), little bluestem, big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), purple top, Elliott bluestem, splitbeard, broomsedge, and tall dropseed (*Sporobolus asper*). The second objective was to evaluate which broadleaf species resisted the effects of the herbicide. The first study was a randomized-block experiment implemented at 4 sites in the outer bluegrass and Missippian Plateau region of Kentucky. We evaluated the use of 0.21 kg ai/ha Clethodim and 0.21 kg ai/ha Imazapic against an untreated control in 0.1 ha treatment plots that were approximately 50% native warm season grasses and 50% tall fescue. A methylated seed oil surfactant at 2.3L/ha and 28-0-0 liquid fertilizer were including with all herbicides following manufacturer's recommendations. All herbicides were sprayed with a Demco™ spray unit delivering a spray volume of 187 L/ha at 414 kPa through Tee-Jet 8003 flat fan nozzles attached to an all-terrain vehicle driven at a constant speed of 2 - 3 kph. The herbicides were applied at two different time periods, one in late March and the second spraying in mid-April. The second study evaluated the use of 0.2 kg ai/ha Clethodim, 0.21 kg Imazapic ai/ha, and 0.03 ai/ha sulfosulfuron against an untreated control in a completely randomized experiment at 14 locations representing most of the physiographic regions across Kentucky. Individual treatment plots were 3 x 10m and the herbicide was applied with a backpack sprayer delivering 187 L/ha at 414 kPa through Tee-Jet 11002 flat fan nozzles while walking at a constant rate of 2 - 3 kph. In the first study, both the Clethodim and Imazapic treated plots worked at removing the tall fescue irrespective of the spraying date. The amount of tall fescue was reduced from an average of 42.5% to less than 1% in all the treatment plots irrespective of the herbicide used. By the end of the second year, the percent fescue began increasing in the Clethodim treated plots and not the Imazapic treated plots. The NWSG responded to the herbicide treatments and was increased in all plots except the plots sprayed with Clethodim in April. The Imazapic plots had higher percent NWSG cover than the Clethodim plots irrespective of time of herbicide application and averaged 41.8%, 25,8%, 52.8% and 55% in the early and late Clethodim plots and the early and late Imazapic plots respectively.
The percent tall fescue in the pre-treatment plots from the second study ranged from 25 to 70% and NWSG percent ranged from 40 to 50%. Total vegetative cover averaged across all 14 sites was 92.8% and tall fescue cover averaged 45.9%. The mean cover by the NWSG was 39.6% with an average species richness of 6.1. As expected, all three herbicides provided substantial efficacy in killing tall fescue. The average percent tall fescue was 7.8%, 1.2%, and 3.8% in the Clethodim, Imazapic, and Sulfosulfuron plots respectively. The percent cover in the Imazapic and Sulfosulfuron plots was higher than the Clethodim plots and averaged 74.6%, 60.5%, and 39.2% respectively. The amount of bare ground was similar between treatments and averaged between 20. 5 to 29.4%. Species richness was also similar although the Clethodim plots had a higher average number of species. Typical groups of broadleaf plants or wildflowers that appeared to resist the effectiveness of the herbicides were typically in the composite or legume family. Managers should proceed with caution because in some cases, invasive exotic species like crown vetch or sweet clover invaded plots where the fescue was eliminated. This information shows that herbicides can be used to restore native grasslands but more information is needed to determine which additional species of broadleaf plants or wildflowers resist the effects of various herbicides.

2003 North Central Weed Science Proceedings 58:123.

CIMARRON MAX: WEED CONTROL IN RANGELAND AND IMPROVED PASTURE.

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Metsulfuron methyl, 2,4-D amine and dicamba (Cimarron Max), a new product offering from DuPont Crop Protection that provides residual and postemergence weed control in rangeland and improved pasture. Clipping studies were conducted to evaluate differences in forage production of native and introduced grasses. Field trials measured grass response and weed control following applications of metsulfuron methyl, 2,4-D amine and dicamba in rangeland and improved pasture. Research showed excellent results on broadleaf weeds including western ragweed, musk thistle, Scotch thistle, and broom snakeweed. The clipping studies showed near 100% biomass reduction of horsenettle, silverleaf nightshade, horseweed, and bitter sneezeweed with a 1 to 3-fold forage increase when metsulfuron methyl, 2,4-D amine and dicamba was used.

CHEMICAL CONTROL OF SERICEA LESPEDEZA IN NEBRASKA. Robert A. Masters, Rangeland Scientist, Dow AgroSciences, LLC., Lincoln, NE 68506.

Sericea lespedeza is perennial invasive and noxious weed in central Great Plains of the United States. In this region the species commonly infests rangeland, pastures, roadsides, and rights-of-way. On rangeland and pastures, infestations often reach densities that reduce livestock carrying capacity and wildlife habitat quality. These reductions result, in part, from direct interference of this plant with desirable forages and browse. In addition, sericea lespedeza is not palatable to beef cattle or native ungulates because leaves and stems contain a high level of tannin. Research was initiated at a pasture site in southeast Nebraska to determine the response of sericea lespedeza to several herbicides including triclopyr + fluroxypyr, picloram + fluroxypyr, triclopyr, metsulfuron and dicamba + diflufenzopyr. Herbicides were broadcast post-emergence applied on June 29, 2002 to plots that were 3 by 10 m in size. Sericea lespedeza plants were at the vegetative growth stage when herbicides were applied. The most effective treatments within 90 days after application contained triclopyr and/or fluroxypyr. By 14 months after treatment, fluroxypyr + triclopyr at 315 + 105 g ae/ha or 420 + 140 g ae/ha, triclopyr at 840 g ae/ha, and picloram + fluroxypyr at 188 + 188 g ae/ha provided greater than 90% control. In contrast, sericea lespedeza control provided by metsulfuron at 21 g ae/ha or dicamba + diflufenzopyr at 210 + 84 g ae/ha was less than 50%. Triclopyr- and fluroxypyr-containing herbicides provided the best sericea lespedeza control over the period of two growing seasons during which this experiment was conducted.

IMPACT OF STAGE OF GROWTH AND WEATHER ON SERICEA LESPEDEZA CONTROL USING HERBICIDES. Walter H. Fick, Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Sericea lespedeza has been a state wide noxious weed in Kansas since July 1, 2000. Previous screening studies have indicated that triclopyr and metsulfuron are the most effective herbicides for sericea lespedeza control. Studies conducted at a site near Maple Hill, KS from 1998-2002 were evaluated to determine the impact of stage of growth and environmental conditions at the time of herbicide application on sericea lespedeza control. Herbicides included in this study were triclopyr, metsulfuron, and fluroxypyr. These herbicides were applied in 20 gpa spray volumes using a CO_2-powered four-nozzle boom sprayer equipped with 8004 flat fan nozzles. Stage of growth at the time of herbicide application ranged from late vegetative to seed production. Individual plots were 6.7 by 25 feet with treatments replicated four times. Treatments were evaluated for percent control about 1 year after treatment. Control with 0.5 lb/acre triclopyr ranged from 41-99% with an average of 68%. Metsulfuron at 0.24-0.3 oz/acre averaged 63% control with a range from 4-99%. Fluroxypyr at 0.19-0.25 lb/acre provided 60% control with a range from 14-84%. Control was generally equal among treatments applied during the late vegetative stage except in 2002. A combination of 0.38 lb/acre triclopyr + 0.13 lb/acre fluroxypyr provided 90% control of sericea lespedeza treated on July 3, 2002. Triclopyr (0.5 lb/acre) and metsulfuron (0.3 oz/acre) provided only 65 and 20% control, respectively. Rainfall during June and July, 2002 was 45% of normal. Limited rainfall during July in 1999 and 2000 also reduced control using triclopyr, metsulfuron, and fluroxypyr. Metsulfuron (0.24 oz/acre) provided 92% control when applied on September 18, 1998 during full bloom. Triclopyr (0.5 lb/acre) and fluroxypyr (0.19 lb/acre) provided only 60 and 72% control, respectively. Sericea lespedeza produced few flowers during 2000 due to extremely dry weather (29% of normal for July-September). Spraying under these conditions resulted in less than 25% control with any of the herbicides. Stage of growth and growing conditions at the time of herbicide application can greatly influence the effectiveness of most herbicides used for sericea lespedeza control.

CULTIVATION TIMING USING *WEEDCAST* FOR IMPROVED WEED CONTROL IN POTATO.
George O. Kegode, Jerry Ivany, Joel Felix, and Douglas J. Doohan. Assistant Professor, Research Scientist, Postdoctoral Research Associate, Associate Professor. North Dakota State Univ., Fargo, ND 58105; Agriculture and Agri-Food Canada, P.O. BOX 1210, Charlottetown, PE C1A 7M8, Canada; and The Ohio State University, Wooster, OH 44691.

The *WeedCast* computer model was evaluated as a decision aid to determine cultivation timing in potato at Fargo, ND; Wooster, OH; and Charlottetown, PEI, Canada from 2001 to 2003. A split-plot arrangement of treatments in a randomized complete block design with cultivation time as the main plot and herbicide as subplot was used. Main plots were cultivated when the model predicted 0, 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, 0% predicted weed emergence, were cultivated only at layby. Otherwise, potatoes were grown using standard cultural practices as recommended by the respective extension services. Cultivation timing was predicted using *Solanum ptychanthum* and *Amaranthus retroflexus* in 2002 and 2003, respectively, at Fargo; *A. retroflexus, Polygonum pennsylvanicum*, and *Chenopodium album*, in 2001, 2002, and 2003, respectively at Wooster; and *C. album* at Charlottetown all years. In 2001, cultivation timing based on 15% predicted emergence of *A. retroflexus* (Wooster) and *C. album* (Charlottetown) resulted in better weed control and tuber yield. In 2002, cultivation at 30% predicted emergence of *S. ptycanthum* and *P. pennsylvanicum* provided the best weed suppression at Fargo and Wooster, respectively; whereas at Charlottetown, 15% predicted emergence of *C. album* resulted in the best weed control. In 2003, three cultivations done at 15, 30, and 60% predicted weed emergence provided the best weed control and lowest weed biomass yield when compared with two cultivations at 30 and 60% predicted weed emergence, or one cultivation at 60% predicted weed emergence. Cultivation alone did not adequately control all weeds, and at all three sites potato that was only cultivated tended to yield less than cultivation + herbicide treatments. We conclude that timing cultivation to 15% predicted emergence using *Weedcast* appears to be an effective tool for improving weed management in potato.

APPLE OF PERU: AN EMERGING WEED IN VEGETABLE AND FIELD CROP ROTATIONS. Douglas Doohan[1], Joel Felix[2] and John Cardina[1], [1]Associate Professors and [2] Research Associate, Department of Horticulture and Crop Science, The Ohio State University, Wooster, 44691.

Apple of Peru (*Nicandra physalodes*) is an emerging invasive weed that threatens field- and vegetable-crop production in the eastern United States. Epicenters of infestation are established in OH, NC, TN, and GA. Within these locations apple of Peru is found in fields where soybeans and vegetables are grown in rotation, in ornamental field nurseries and in peanut. Acres infested have not been determined; however, the OH infestation is estimated at 2000-3000. Regional floras indicate that apple of Peru has been in OH since at least the late 1890's, but never considered troublesome. Globally, apple of Peru is a serious weed of cotton, soybean, peanuts, dry beans and corn in Asia, Australia, and east Africa. It is one of the most important weed problems in soybeans and corn in Brazil. In August 2002 we identified this species in several bell pepper and processing tomato fields in north-central OH. In each instance apple of Peru had survived intensive weed control practices including herbicide use and cultivation. Late summer density in one pepper field averaged 1.8/ square m, with a range from 0.1 to 12 plants/ square m. Funding from North Central Pest Management Center, supported an OH-wide survey in 2003. Infestations were detected with assistance of crop scouts and agents and then confirmed and delineated by laboratory staff. Results confirmed restriction of agricultural infestations to the north-central counties of Sandusky and Seneca, but scattered, small patches were found within or in close proximity to arable fields in other parts of the state. In north-central OH, pepper fields were severely infested in 2003, as in 2002. In early September plants ranged from emerging seedlings to individuals more than 210 cm tall and with stems 4 cm in diameter. Late emerging apple of Peru produced seed in corn fields treated with atrazine and mesotrione. We observed some plants producing seed in soybean that had been treated with glyphosate. Plants were apparently 90 cm tall at the time of herbicide application. The terminal shoot had died back about 30 cm at which point axillary buds produced new flowering shoots. Other individuals in the same field died.

EFFECT OF PHOTOPERIOD ON GROWTH OF FIVE SOLANACEOUS WEEDS. Joel Felix and Douglas J. Doohan, Research Associate and Associate Professor, The Ohio State University/OARDC Wooster, OH 44691.

Temperature and photoperiod are the two most important environmental variables influencing the rate of development in many plants including weeds. Our objective was to quantify the effect of photoperiod on growth and reproduction of eastern black nightshade (*Solanum ptycanthum*), smooth groundcherry (*Physalis subglabrata*), clammy groundcherry (*Physalis heterophyll*), horsenettle (*Solanum carolinense*), and apple of Peru (*Nicandra physalodes*). Light-shielded tents were setup in a greenhouse room at 28/16C (day/night) to provide plants with one of the following light/dark regimes; 10/14hrs, 14/10hrs, 16/8hrs.

Response to photoperiod was observed for all species. All plants were smallest when exposed to 10/14 hr light/dark regime; with horsenettle and clammy groundcherry not flowering even after 120 days. Flower buds were initiated 15 days after emergence (DAE) for apple of Peru and 17 DAE for eastern black nightshade under 10/14 hr regime. When exposed to 14/10 and 16/8 hrs of light/darkness, apple of Peru and eastern black nightshade flowered 31 DAE compared to 60 days for clammy and smooth groundcherry. Horsenettle flowered 97 DAE under 14/10 and 16/8hrs regimes, but did not set seeds, probably due to lack of pollinating agents in the tents.

Under the 10/14 hr regime, apple of Peru plants averaged 376 cm^2 leaf area compared to 211 cm^2 for eastern black nightshade at flowering. Leaf area for apple of Peru and eastern black nightshade growing under 14/10 hr was 698 and 1067 cm^2, respectively. Apple of Peru and eastern black nightshade exposed to 16/8hrs of light/darkness averaged 1528 and 1159 cm^2 of leaf area at flowering. Leaf area for common- and clammy groundcherry growing under 14/10hrs was 2405 and 2444 cm^2, respectively. When exposed to 16/8hrs, common- and clammy groundcherry averaged 3047 and 3051 cm^2, respectively. Seed set for common and clammy groundcherry was very poor probably due to lack of pollinating agents. Seed production was lowest for apple of Peru and eastern black nightshade growing under 10/14 light/darkness regime. Results suggest that apple of Peru and eastern black nightshade germinating in late summer or in crop-shaded canopies have an ability to produce seeds that will contribute to soil seedbanks.

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

Wild Oat has become 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. It is well documented that wild oats can be controlled with herbicides. However, with increasing herbicide resistant populations, and environmental concerns, the understanding of wild oat growth and development and environmental affects is needed for optimum and consistent control. The objectives of this experiment are to evaluate the growth and development of wild oats, determine if later emerging wild oat plants have an accelerated rate of growth compared to early emerging wild oat plants, and evaluate environmental effects on wild oat growth and development. Research plots were established at two locations in 2002 and 2003; Fargo, North Dakota and Crookston, Minnesota to evaluate the growth and development of wild oat. Four emergence cohorts were selected; cohort 1 emerged 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 and numbered. On a weekly basis, individual plants were evaluated for height, leaf number on main culm, number of tillers and total leaves. Flag leaf emerged and date of heading were also 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 a similar trend in growth. 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 similar to one another and were always larger than cohort 4. Cohort 1 had the greatest seed production than the other three cohorts. Cohort 2 and 3 had less seed production than cohort 1 but more than cohort 4, and cohort 4 had the lowest seed production The latest emerging wild oat plants grew as faster or faster than earlier emerging wild oat plants, and cohorts 3 and 4 have a shortened growing season. This research indicates that growth and development of wild oat may be predicted based on growing degree days. 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.

IMPACT OF SPRING-APPLIED, RESIDUAL HERBICIDES ON WINTER ANNUAL WEED POPULATIONS AFTER CROP HARVEST. Jeff W. Barnes, William G. Johnson, Kelly A. Nelson, and Reece A. Dewell, Post-Doctoral Research Associate and Assistant Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907. Purdue University, West Lafayette, IN 47907; Research Assistant Professor Greenley Research Center, University of Missouri, Novelty, MO 63460; Post-Doctoral Research Associate, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Field experiments were conducted in Missouri during 2001 through 2003 to determine if applications of preemergence (PRE) corn and soybean herbicides would impact the populations of winter annual weeds one year after herbicide application. Residual herbicides were applied PRE prior to planting corn and soybean. In-season weed control was provided by postemergence applications of glyphosate. In the fall following corn and soybean harvest, winter annual weeds were counted in two 1-m2 areas per plot. These areas were marked in the fall and counts were made in early February, April and prior to planting the corn or soybean crop.

The dominate species in these trials were henbit and common chickweed with populations of other winter annual species relatively low and highly variable. Herbicide applications made prior to planting the crop in 2001 and 2002 were generally effective in reducing henbit populations in the fall of those years but by late-spring populations of henbit and common chickweed were similar to the non-treated control. There was a high degree of natural mortality of henbit and common chickweed during both the winters of 2002 and 2003. If winter annual mortality was lower, as would occur during a milder winter, the residual effect of the herbicides might have had a greater impact on spring populations.

WEED SEED FATE IN SOIL SEEDBANKS: NC202 REGIONAL RESULTS. Adam S. Davis*, Karen A. Renner, John Cardina, Frank Forcella, Gregg A. Johnson, John L. Lindquist, Ed C. Luschei, Marty M. Williams II, Christy L. Sprague, Research Associate and Professor, Michigan State University, East Lansing, MI 48824; Associate Professor, Ohio State University, Wooster, OH 44691; Research Agronomist, USDA-ARS Soil Lab, Morris, MN 56267; Research Agronomist, University of Minnesota Southern Research and Outreach Center, Waseca MN 56093; Associate Professor, University of Nebraska, Lincoln, NE 68583; Assistant Professor, University of Wisconsin, Madison, WI 53706; Assistant Professor, Washington State University, Prosser, WA, 99350; Assistant Professor, University of Illinois, Urbana-Champaign, IL 61801.

Weed seedbanks are primarily responsible for recurring infestations of annual weeds. Yet the amount of variation in weed seedbank persistence in the soil and factors regulating this parameter are poorly understood. A field experiment was initiated by the NC202 regional weed management working group to determine the range of variation in weed seedbank decline in MI, OH, IL, WI, MN, NE and WA. In October of 2001, freshly harvested seeds of common lambsquarters, giant foxtail and velvetleaf were buried within 0.5 mm mesh nylon bags at depths of 0, 2 and 10 cm. Two bags per species were buried at each depth, each containing one hundred seeds. One bag in each pair was recovered in April and the other bag was recovered the following October for the determination of seedbank decline during the winter and summer months, respectively. Seed viability was determined through germination tests and tetrazolium assays. Seedbank decline for both the winter and summer months varied between locations ($P<0.001$) and species ($P<0.001$). During the overwinter burial period, common lambsquarters seed mortality ranged from 5% in NE to 50% in WA, giant foxtail seed mortality ranged from 10% in NE to 40% in IL, and velvetleaf seed mortality ranged from 3% in OH to 35% in NE. During the period from April 2002 through October 2002, seedbank decline (including both seed mortality and seed loss due to germination) varied from 22% in MI to 45% in MN for common lambsquarters, from 50% in IL to 95% in MN for giant foxtail, and from 18% in IL to 85% in WI for velvetleaf. Annual rates of seedbank decline ranged from 30% in MN to 80% in WA for common lambsquarters, from 70% in MI to 95% in MN for giant foxtail, and from 30% in OH to 90% in WI for velvetleaf. During both burial periods, significant depth by species interaction effects ($P<0.001$) indicated that seedbank decline for ABUTH and CHEAL was greatest at the 0 cm depth and lowest at the 10 cm depth, whereas seedbank decline for SETFA did not vary in a consistent way with depth. In multiple regression models for each species, burial depth, precipitation and mean air temperature all made small (< 5%) contributions to explaining variation in overwinter seedbank mortality. Unexplained location effects were consistently the most important variable in the models, explaining up to 45% of the variation in the response variable. A tremendous amount of variation exists in the rate of weed seedbank decline across the North Central Region. To make use of such variation in management strategies, however, additional controlled experiments isolating environmental and management variables will be necessary.

MODELING MULTIPLE WEED SPECIES INTERFERENCE IN CORN. J. Anita Dille, Stephanie R. Deines, Eric L. Blinka, David L. Regehr, and Scott A. Staggenborg, Assistant Professor, Former Graduate Research Assistant, Graduate Research Assistant, Professor, and Associate Professor, Kansas State University, Department of Agronomy, Manhattan, KS 66502.

Field studies were conducted to compare corn yield loss caused by common sunflower and shattercane populations to predicted yield losses modeled using an additive function, WeedSOFT®, or a multiple species rectangular hyperbolic model, and to derive competitive index values for common sunflower and shattercane when interfering with corn. Common sunflower and shattercane emerged with corn and were established at selected densities within 15 cm on either side of the corn row in experiments at Scandia and Rossville, Kansas between 2000 and 2002. Weed-free corn yield ranged from no harvestable yield at Scandia in 2001 to 5,380 kg ha^{-1} at Scandia in 2000 and 11,735 kg ha^{-1} at Rossville in 2001. Maximum predicted yield losses ranged from 27 to 69%. Low density mixed populations of common sunflower and shattercane caused less than additive yield losses. The current WeedSOFT® yield loss model under-predicted yield losses. The multiple species rectangular hyperbolic model was appropriate and indicated that intra- and inter-specific interference was occurring at very low densities. When common sunflower was assigned a competitive index value of 10, the competitive index for shattercane ranged from 0.5 to 1.6 indicating that common sunflower was 6.25 to 20 times more competitive than shattercane when interfering in corn across all locations and years except at Rossville in 2001 when they were equally competitive.

HERBICIDE- FUNGICIDE INTERACTION IN SOYBEAN. Rebecca E. Bierman, Dean E. Riechers, Christy L. Sprague†, German Bollero and Wayne L. Pedersen, Graduate Research Assistant, Assistant Professor, Assistant Professor, Assistant Professor and Associate Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801 and †Michigan State University, East Lansing, MI 48824.

Fungicide seed treatments are becoming increasingly popular for use with glyphosate-tolerant soybeans. A two year field study was conducted to determine whether certain combinations of fungicide seed treatments and POST-applied herbicides affect soybean yield. Thirty-six treatments were evaluated, involving six fungicides [thiabendazole (TBZ), pentachloronitrobenzene (PCNB), captan, TBZ + PCNB + captan (Rival) and 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 set up as a split-plot within a randomized complete block design, with seed treatment as the main plot and herbicide as the sub-plot. This study was conducted at three locations across Illinois during the summers of 2002 and 2003, with four replications in each of the six environments.

This experiment was initiated in response to preliminary data suggesting possible negative interaction between certain herbicides and fungicides. Specifically, there was concern of a negative yield effect associated with the combination of Rival, or one of its components (TBZ, PCNB and captan) and imazethapyr. This study was designed to determine whether significant differences exist between the yields of any of these treatments and those of a chemical –free control. All fields had minimal disease pressure and were kept weed-free (mechanically), allowing for the evaluation of chemical interactions independent of the confounding factors of herbicide and fungicide efficacy. Analysis of our data shows that only the no herbicide + Maxim treatment yielded differently than the chemical -free control. Neither fungicide, herbicide, nor fungicide x herbicide significantly affected crop yield. Crop injury after herbicide application was also evaluated. Statistical analysis showed a significant fungicide x herbicide effect on crop injury at seven days after treatment, at alpha= 0.06. However, within each herbicide, none of the fungicides differed from the untreated control. No evidence was found to indicate that any of these chemical interactions affect yield. Earlier reports of fungicide x herbicide interactions, and the variation in crop injury we observed within this study, may reflect root health issues. We speculate that plants with healthier root systems may be able to better withstand environmental stresses encountered later in the growing season, whether they are due to disease pressure, weather or herbicide application.

SIMULATED AUXINIC HERBICIDE TANK CONTAMINATION EFFECTS ON SOYBEAN GROWTH, DEVELOPMENT, AND YIELD. Kevin B. Kelley, Loyd M. Wax, Aaron G. Hager, and Dean E. Riechers, Graduate Research Assistant, Professor Emeritus, and Assistant Professors, Department of Crop Sciences, University of Illinois and USDA-ARS, Urbana, IL 61801.

Several plant growth regulator (PGR) herbicides are used for weed control in corn and wheat production systems. Soybean are very sensitive to PGR herbicides and are often grown next to corn and wheat fields. Symptoms resembling PGR herbicide injury are frequently reported in soybean fields. Soybean may be exposed to PGR herbicides by off-target movement of spray particles, volatilization, or from residues that can be dislodged from application equipment following a previous application to a corn or wheat crop. Previous experiments have shown that simulated drift of PGR herbicides can cause a high level of injury to soybean yet not have as significant of an effect on yield. The current study was initiated to determine if the presence of PGR herbicides with commonly used soybean herbicides (as in the case of PGR herbicide residues dislodged from application equipment) would result in increased crop response and yield effect when compared with the PGR herbicide applied alone at an equivalent rate. In 2002 and 2003, the highest labeled use rates of the herbicides glyphosate, imazethapyr, imazamox, and fomesafen were applied alone and in combination with 1% of a field use rate of dicamba at two vegetative growth stages (V3 and V7) of glyphosate-resistant soybean. Dicamba was also applied alone. Crop injury, plant height, yield, and yield components (seed weight, seeds per pod, pods per plant) were evaluated both years. The rate of dicamba used killed the soybean apical meristem in all treatments, with all subsequent growth occurring from branches. Dicamba-treated soybean were shorter and yielded less than soybean from other treatments. Additionally, at the later application (V7), imazethapyr, imazamox, and fomesafen caused a greater yield reduction when combined with dicamba than did dicamba applied alone. Glyphosate did not significantly affect dicamba-induced yield reductions in either year. The yield component that was most affected at the V7 application was seeds per pod. These results indicate that dicamba can have a greater effect on soybean development and yield if other herbicides are present to cause additional stress to the plant, though the magnitude of response is affected by the herbicide used and the growth stage of the soybean.

EFFECT OF TIMING ON FALL APPLIED HERBICIDES. Ryan F. Hasty, Christy L. Sprague, Aaron G. Hager, and Bill Simmons. Graduate Research Assistant, University of Illinois, Urbana, IL 61801; Assistant Professor, Michigan State University, East Lansing, MI 48824; Assistant Professor, and Associate Professor, University of Illinois, Urbana, IL 61801.

Experiments were conducted in the fall of 2001 and 2002 to determine the optimum timing of fall herbicide programs for early-season weed control prior to soybean in Illinois. Herbicide treatments included chlorimuron plus sulfentrazone plus tribenuron, flumetsulam plus metribuzin, imazaquin plus glyphosate, and a non-residual control (paraquat) with six application timings based on soil temperatures ranging from 22 to -1.1 C. There was an increase in weed biomass collected 2 weeks after planting (WAP) in the non-residual control with applications made later in the season. Application timings within residual herbicides were not different with respect to soybean yield and control of giant foxtail, common lambsquarters, fall panicum, and common waterhemp when applied according to label specifications (application after harvest and prior to ground freeze). Residual herbicides controlled >90% of common chickweed, mouseear chickweed, henbit, and annual bluegrass, regardless of application timing. The main effect of timing was not significant for any dependent variable tested. The main effect of herbicide resulted in differences in control of fall panicum and common waterhemp with chlorimuron plus sulfentrazone plus tribenuron > flumetsulam plus metribuzin> imazaquin plus glyphosate.

GLYPHOSATE EFFICACY ON GIANT RAGWEED INFESTED WITH EUROPEAN CORN BORER. Eric J. Ott, William G. Johnson, John L. Obermeyer, and Dan J. Childs, Graduate Research Assistant, Assistant Professor of Weed Science, Department of Botany and Plant Pathology Purdue University, West Lafayette, IN 47907-2054, IPM Supervisor, Department of Entomology Purdue University, West Lafayette, IN 47907-2089, Agronomist, Deiner Seeds, Reynolds, IN 47980.

Glyphosate occasionally fails to control giant ragweed. Closer investigation of some escaped plants reveals the presence of stalk boring insects and tunneling. Greenhouse and field studies were conducted to evaluate the influence of stalk boring insects on giant ragweed control with glyphosate. In the greenhouse study, ninety-six giant ragweed seedlings 3- to 5-cm tall were collected from the Purdue University Agronomy Center for Research and Education near West Lafayette, IN at three different times, placed in plastic pots, fertilized and placed in a greenhouse. When the giant ragweed plants were 6- to 8-cm tall, 48 of the plants where infested with 2- to 4-European corn borer *(Ostrinia nubilalis)* neonates. When the giant ragweed reached a height of 13- to 15-cm, 24 infested and 24 non-infested plants were selected to be sprayed with four different rates of glyphosate (0 kg ae/ha, 0.63 kg ae/ha, 0.76 kg ae/ha, 1.52 kg ae/ha). When the 48 remaining plants reached a height of 40- to 44-cm, they were treated with glyphosate as described earlier. European corn borer tunnel length and giant ragweed dry weights were recorded 21 days after treatment. This experiment was conducted three times. Plants that were 13 -to 15-cm tall when sprayed showed reduction in dry weight with increased length of European corn borer tunneling in all treatments including untreated checks. The plants that were 40 –to 44-cm tall when sprayed showed similar results except at the 0.63 kg ae/ha rate. In this treatment, as the length of European corn borer tunneling increased, giant ragweed dry weight increased as well. In many of the plants in this treatment, axillary shoots were produced below where European corn borer had bored, and giant ragweed continued to grow. Glyphosate efficacy, with lower rates, was reduced in larger plants infested with European corn borer. In field studies, new cohorts of giant ragweed seedlings were initiated on two week intervals beginning in late May by tilling strips of ground in an area with a natural infestation of giant ragweed. Glyphosate was applied at the rates and weed sizes listed earlier. This experiment was repeated in time at two and four weeks after the initial tilling. Preliminary results indicate that most natural occurring infestations of giant ragweed take place 12.5±7 cm above the soil surface. Many of the escaped plants in the field showed similar characteristics with what was seen in the greenhouse study.

GLYPHOSATE RESISTANT HORSEWEED (*CONYZA CANADENSIS*) CONTROL IN NO-TILLAGE SOYBEANS. Vince M. Davis*, William G. Johnson, Jeff W. Barnes, and Kevin D. Gibson, Research Assistant, Assistant Professor, Post-Doctoral Research Assistant, Assistant Professor of Weed Science, Purdue University, Dept. Botany and Plant Pathology, Lilly Hall, 915 W. State Street, West Lafayette, IN 47907-2054

Glyphosate resistant horseweed is a growing threat in no-tillage soybean production across the North Central region. Glyphosate resistant horseweed was first reported in Delaware in 2000 and has since been reported in several other states including Indiana, Ohio, Tennessee, Kentucky, and Arkansas. Tillage is an effective management approach, but it is important to find other integrated solutions for the preservation of existing no-tillage fields. The objective of this experiment was to evaluate the efficacy of glyphosate alone and in tank mix combinations on control of glyphosate resistant horseweed in a mixed resistant and susceptible horseweed population. A randomized complete block design field experiment was evaluated in 2003 near Sellersburg, IN. Glyphosate was applied alone at (862.4g ae/ha) and in combination with cloransulam-methyl (17.6g ai/ha), chlorimuron-ethyl (17.5g ai/ha), flumioxazin (35.7g ai/ha), flumetsulam (56g ai/ha), imazaquin (136.5g ai/ha), metribuzin (279.8g ai/ha), and sulfentrazone (210g ai/ha) 12 days before planting. Horseweed biomass reduction ratings were taken at 12, 22, 39, and 55 days after treatment (DAT). Glyphosate plus cloransulam-methyl, chlorimuron-ethyl, flumioxazin, and flumetsulam all provided significantly better horseweed control than glyphosate alone. Glyphosate plus sulfentrazone significantly improved horseweed control at 55 DAT only. Glyphosate plus imazaquin and metribuzin resulted in lower control than glyphosate alone at 12 DAT. However, glyphosate plus imazaquin provided similar control to glyphosate alone at 22, 39, and 55 DAT. Glyphosate plus metribuzin provided similar control to glyphosate alone at 22 and 39 DAT and better control than glyphosate alone at 55 DAT.

PROWL H_2O: A NOVEL WATER-BASED FORMULATION OF PENDIMETHALIN. Jon K. Sweat, Paul M. Vassalotti, Gary M. Fellows, Troy D. Klingaman, Leo D. Charvat and Dan E. Westberg, Technical Market Manager, Senior Technical Service Representative, Technical Market Manager, Biology Area Manager, Biology Area Manager and Biology Group Leader, BASF Corporation, Research Triangle Park, NC 27709.

Prowl® H_2O is a new aqueous capsule suspension formulation of pendimethalin. It contains 456 grams of active ingredient per liter. The encapsulation of pendimethalin allows for the elimination of organic solvents in the product. This reduces odor, staining, volatility and surface residue adhesion, as compared to existing emulsifiable concentrate formulations of pendimethalin. It is stable under conditions of freezing and thawing and is compatible with liquid and dry fertilizer. Prowl H_2O is registered for use in corn (field, pop, seed and sweet), cotton, edible beans, garlic, grain sorghum, lentils and peas, nonbearing fruit and nut crops, nonbearing vineyards, onions and shallots (dry bulb), peanuts, potatoes, rice, soybeans, sugarcane, sunflowers and tobacco. Prowl H_2O received section 3 registration on March 26, 2003.

PROWL H_2O: FIELD PERFORMANCE. Troy D. Klingaman, Leo D. Charvat, Dan E. Westberg, Jon K. Sweat, Paul M. Vassalotti, and Gary M. Fellows. Biology Area Manager, Biology Area Manager, Biology Group Leader, Technical Market Manager, Senior Technical Service Representative, and Technical Market Manager, BASF Corporation, Research Triangle Park, NC 27709.

Field efficacy and crop tolerance trials were conducted with Prowl® H_2O, a new aqueous capsule suspension formulation of pendimethalin from 1998-2003. A consistent trend for improved crop safety was present with Prowl H_20 compared to pendimethalin emulsifiable concentrate (EC) formulations in all crops tested. The absence of organic solvents in the aqueous formulation results in increased tank-mix flexibility and reduced crop response compared with the EC formulations of pendimethalin. Weed efficacy of both grasses (including *Setaria spp., Digitaria spp., Panicum spp*.) and broadleaves (including *Abutilon theophrasti, Chenopodium album, Amaranthus retroflexus, Amaranthus tuberculatus)* with the aqueous capsule suspension formulation of pendimethalin shows a consistent trend for increased weed control compared with the pendimethalin EC formulations. Prowl H_2O was shown to have reduced binding to crop residues in both lab and greenhouse experiments. The reduced binding of the aqueous formulation was reflected in increased weed control in no-till soybean field trials with either fall or early preplant applications when compared to the EC formulation.

INTERGRATING PHYSICAL AND CULTURAL METHODS OF WEED CONTROL – EXAMPLES FROM EUROPEAN RESEARCH. Bo Melander, Senior Scientist, Danish Institute of Agricultural Sciences, Research Centre Flakkebjerg, DK-4200 Slagelse, Denmark.

A major factor driving research in physical and cultural weed control methods in Europe for the last 15 years has been an increasing concern about pesticide usage. Consequently, governmental actions have been taken in the Nordic countries and the Netherlands to introduce action plans to cut pesticide usage significantly. An increasing conversion to organic farming, favourably subsidised by some European governments, has followed this pesticide policy and further increased the need for knowledge on non-chemical weed control.

Row crops grown at 30-70 cm row spacing, such as vegetables, maize, potatoes and sugar beets, present two different situations for physical weed control of entirely different difficulty. Inter-row weeds are easily removed by ordinary inter-row cultivation while intra-row weeds, *i.e.* those growing between the crop plants in the rows, still constitute a major challenge. Hand weeding intra-row weeds in *e.g.* carrots and direct-sown onion is an appreciable financial burden in organic cropping and where herbicide effectiveness is insufficient in the conventional situation. A number of investigations have focussed on optimising the usage of mechanical weeding principles against intra-row weeds, such as harrowing, brush weeding, hoeing, torsion weeding and finger weeding. These methods have been successful in some row crops, such as transplanted vegetables, potatoes, maize and canola, and may become alternatives to chemical control. However, current intra-row mechanical methods generally work with low selectivity, as they do not distinguish between weed and crop plants. The need for thermal and cultural methods to act in combination with the mechanical ones became evident especially in slow emerging crops with low initial growth rates, where physical intra-row weed control is difficult to conduct. Pre-emergence flaming now plays an important role in creating better conditions for mechanical post-emergence control, and late cover cropping to suppress late emerging weeds might be a useful solution to end a weed control programme in crops with poor canopy closure.

Although the need for hand weeding has been reduced markedly, partly thanks to the achievements in research, it is still a major objective to eliminate the need. The direction in non-chemical research has thus moved to new methods. Robotic weeding is now investigated for row crops with abundant and precise spacing between individual plants, and band-steaming prior to sowing row crops developing dense crop stands in the row show promise of effective and prolonged control.

The tactical use of mechanical weed control methods in small grain cereals has been another area of interest. Weed harrowing gives high work rates but operates with low selectivity meaning that high weed control might be associated with severe crop damages. In contrast, inter-row hoeing does not impact on the crop plants directly and is thus less harmful to the crop but work rates are low. Both methods provide the best results when they become part of a strategy that also involves cultural methods. Combinations with cultural methods such as fertiliser placement, variety choice, crop seed vigour and crop seed rate may improve the outcome of mechanical weed control by improving effectiveness, crop tolerance to mechanical impact and crop competitiveness against weeds escaping control. Mechanical control is widely used in organic cereals, but more propitious tactics have to be developed for conventional cereals.

The European work on non-chemical weed control is discussed and disseminated through the working group: *Physical and Cultural Weed Control* (www.ewrs-et.org/pwc) under the *European Weed Research Society*. The group is also open to people from outside Europe.

WEED RESPONSES TO DIVERSIFIED CROPPING SYSTEMS. Matt Liebman, Paula R. Westerman*, Fabián D. Menalled, and Andrew H. Heggenstaller, Professor, Visiting Scientist, Associate Scientist, and Graduate Research Assistant, Department of Agronomy, Iowa State University, Ames, IA 50011-1010, and *Plant Sciences / Crop and Weed Ecology Group, Wageningen University, 6700 AK Wageningen, The Netherlands.

Although existing data indicate that the diversification of cropping systems can enhance weed control, there is a dearth of information concerning how different rotation systems affect the population dynamics of weed species with contrasting life history characteristics. Moreover, the mechanisms responsible for superior weed control in certain rotation systems are not yet well understood. To address those information gaps, we are conducting a field experiment in Boone, IA, to determine the impacts of 2-, 3-, and 4-yr crop rotation systems on demographic parameters and population dynamics of velvetleaf and giant foxtail. The 2-yr rotation contains corn and soybean, whereas the 3-yr rotation contains corn, soybean, and triticale underseeded with red clover; the 4-yr rotation contains corn, soybean, triticale, and alfalfa. The 2-yr rotation receives conventional rates of fertilizer and herbicides, while the 3- and 4-yr rotations receive reduced rates of chemical inputs.

Soil samples were collected to a depth of 20 cm in November 2002 to assess initial seed bank densities in 7 m x 7 m sub-plot areas of each main plot (18 m x 84 m). Velvetleaf and giant foxtail were detected at low densities (4 ± 2 and 21 ± 7 viable seeds m^{-2}, respectively). Shortly after background seed bank samples were collected, locally produced velvetleaf and giant foxtail seeds were added at rates of 500 and 2000 seeds m^{-2}, respectively, to each sub-plot. Since the time of seed addition, we have measured densities of seeds, seedlings, and reproductive adults of the two weed species. We have also quantified rates of velvetleaf and giant foxtail seed production, as well as rates of weed seed removal by vertebrate and invertebrate seed predators.

In 2003, velvetleaf and giant foxtail seed production was greatest in soybean phases of the 3- and 4-yr rotation systems. Weed seed production was lowest during the corn phase of the 2-yr rotation, and the triticale, red clover, alfalfa phases of the 3- and 4-yr rotations. High levels of weed seed production resulted from greater seedling survival and greater plant size.

Temporal patterns of velvetleaf and giant foxtail seed removal by predators were crop-specific and closely associated with canopy development. Seed predation was greatest when canopies were well developed. Averaged over rotation systems and 12 sampling periods from 14 May to 14 Oct 2003, velvetleaf seed removal rates in corn, soybean, triticale, and alfalfa were 18%, 16%, 21%, and 26% per day, respectively; for giant foxtail, average seed removal rates in corn, soybean, triticale, and alfalfa were 22%, 26%, 26%, and 32% per day, respectively. Catches in pitfall traps and small mammal live traps indicated that field crickets, carabid beetles, and prairie deer mice were the dominant species attacking velvetleaf and giant foxtail seeds.

Depth structured periodic matrix models were used to assess the population growth rate (λ) of velvetleaf in the 2-yr and 4-yr rotation systems (a population is in equilibrium when λ=1). Demographic parameters were drawn from published literature and data generated in our field experiment. Simulation results indicated that requirements for weed control from herbicides and cultivation could be reduced with higher rates of weed seed predation. In the absence of seed predation, velvetleaf populations should decline in the 2-yr rotation (λ=0.93), but increase moderately in the 4-yr rotation (λ=1.17). However, if seed predation in all crop phases of the 4-yr rotation exceeds 24%, velvetleaf populations should decline. Velvetleaf populations should also decline in the 4-yr rotation if 40% of the seeds produced in the soybean phase are removed by predators. Given the observed daily rates of weed seed predation and the fact that no tillage occurs for 26 months after soybean harvest (thus favoring seed retention on the soil surface and exposure to predators), a cumulative loss of 40% of the velvetleaf seeds produced in soybean seems possible.

WHERE ARE THE BIOHERBICIDES? Steven G. Hallett, Assistant Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Since the development and registration of Collego® and DeVine® in the early 1980s, there has been a consistent research effort into the development of bioherbicides. A generally accepted definition since the 1980s has been that a bioherbicide is a weed control product composed of propagules of a living organism applied in a manner analogous to a chemical herbicide. Importantly, the bioherbicide approach has promised effective weed management in intensive cropping systems, where the classical approach (utilizing exotic natural enemies) is largely unsuitable. The over-riding principle of the bioherbicide approach has been that the impact of an organism can be greatly increased when applied at high inoculum doses. The body of research that has been developed over the last two decades has effectively disproved the basic principle of the bioherbicide approach. Furthermore, the suggestion that bioherbicides developed in this way will become competitive with chemical herbicides in mainstream weed management systems should be abandoned.

While research has revealed weaknesses in the bioherbicide approach, it has also revealed significant potential in a number of areas. I argue that as research shifts into these new areas a new understanding of the breadth of the field will emerge and its potential to have genuine impacts upon weed management systems will become apparent. Four key areas for the development of weed biological control are:

1) *Careful selection of niche systems.* Plant pathogens with narrow host ranges can not be used effectively in cropping systems with complex weed communities without a clear understanding of how they may contribute to the overall weed management system. In some cases, it may be feasible to integrate bioherbicides into complex systems for the control of key weed escapes, particularly in minor/specialty crops where there is a lack of herbicide registrations. Better targets, however, are weeds such as the parasitic witchweeds (*Striga* spp.) and broomrapes (*Orobanche* spp.), since controlling these species will deliver significant yield benefits alone.

2) *Investigation of Broad Host Range Bioherbicides*. Plant pathogens such as *Sclerotinia* spp., with wide host ranges have significant potential and should be investigated in greater detail. Fears of non-target impacts should be replaced with epidemiological investigations that measure off-target impacts.

3) *Virulence enhancement.* Without virulence enhancement, bioherbicides will continue to be developed on a case-by-case basis and will always be restricted to niche systems. Different processes for inoculum production and formulation can increase efficacy in some cases, but the bioherbicide approach will only begin to approach its true potential when we begin to develop effective methods for producing genetically modified bioherbicides. Various avenues exist for the improvement of plant pathogens as bioherbicides.

4) *Conservation biological control.* The bioherbicide approach has been rooted in the direct augmentation of natural enemies. The indirect augmentation of natural enemies by the manipulation of natural ecosystems and agroecosystems can also have significant impacts upon weed populations and communities. Research in this area targeting weed management has been largely restricted to the manipulation of insect herbivores, but should be equally applicable to plant pathogens, and conservation approaches can be utilized to impact soilborne microbes that accelerate weed seedbank decline and inhibit weed seedling development.

RESEARCH METHODOLOGIES AND STATISTICAL APPROACHES FOR MULTITACTIC SYSTEMS. Ed Luschei, Assistant Professor, University of Wisconsin, Madison, WI 53706.

Both logic and intuition suggest that multitactic weed control strategies may, on average, produce more favorable weed management outcomes than single tactic approaches. Despite a compelling logical basis, understanding the how agricultural systems respond to multitactic approaches presents researchers with difficulties sufficient to motivate careful consideration of research methodologies. We suggest there are two general classes of objectives: forecasting or decision-making and theory building. The later class can be decomposed into three types: case or proof-of-concept studies, exploration of generality and a search for alternative hypotheses. When the primary research objective is forecasting, one productive experimental approach combines widely dispersed sampling, an explicit representation of uncertainty and consideration of scenarios. Traditional agronomic designs are most suited to proof-of-concept studies, whereas mixed-model approaches are better for exploring generality, and model selection techniques for comparing alternatives. We demonstrate the use of several of these methods using examples from experiments across the state of Wisconsin.

WHEAT SCOUT: DECISION AID FOR INTEGRATED MANAGEMENT OF GRASS WEEDS IN SPRING WHEAT. David Archer, Frank Forcella, Beverly Durgan, and James Eklund, Agricultural Economist, Research Agronomist, Professor, and Engineering Science Technician, USDA-ARS, Morris, MN 56267, and University of Minnesota, St. Paul, MN 55108.

The concept of "weed thresholds" has been useful as it encouraged critical examination of weed management assumptions. However, thresholds, as represented by a single value of weed abundance, should be envisioned only as a reflection of a reality with a single dimension. In multidimensional reality, thresholds should move along a scale of weed abundance. The direction and extent of movement along this scale depends upon a multitude of factors that may alter economic returns due to weed management. Although the effects of one or two of these factors (e.g., herbicide cost, commodity price) on threshold values have been studied, the aggregate effects of multiple factors, and sometimes opposing factors, are much more difficult to judge. Such judgments are especially troubling for practitioners who have little spare time during the early growing season to weigh and integrate the individual effects of several variables on the worth of weed thresholds and control tactics. Consequently, we developed WheatScout software to aid decisions in managing spring wheat regarding the timing and type of control for the two most troublesome grass weeds in the northern Great Plains of the USA and Canada: green foxtail and wild oat (*Setaria viridis* and *Avena fatua*). This tool is an easily used model whose simplicity belies detailed calculations, hidden from users, regarding biology of weeds and wheat, economics, and management. Biological information generated by WheatScout includes (a) micrometeorologically-based simulations of weed and wheat emergence timing and leaf-stage development; (b) weed/crop interference, including effects of differential weed/crop development rates; and (c) weed seed production as functions of weed density and herbicide rate. Management information involves: (a) herbicides appropriate for specific plant growth stages, (b) herbicide dose-responses for each labeled graminicide for control of green foxtail and wild oat, and (c) effects of delayed herbicide application on herbicide efficacy. Economic information entails net returns for each potential herbicide, including those for a range of reduced application rates, at the current scouting date as well as at future evaluation dates.

WheatScout simulates weed and wheat emergence and development after crop sowing. At some point after initial crop and weed emergence, crop scouts, the presumed users, are expected to supply basic information on crop and weed developmental stage (average leaf numbers per plant) and an estimate of weed density. WheatScout recalibrates weed and crop development based upon these inputs. The scout also selects a future evaluation date, such as 7 or 14 days hence. WheatScout then simulates net returns for all appropriate herbicides and rates as if applications were made on the current date or the specified future date. Weed seed production also is simulated. Thus, users can make immediate judgments on the same days that fields are scouted, as well as user-selected future dates. Calculations are based upon actual, forecasted, and/or contrived weather data, as well as recalibration from ground-truthing during scouting activities. Forecasted net returns and weed seed production help scouts and their clients make better and more informed decisions regarding both immediate potential profitability as well as long-term impacts of their weed management choices.

THE MAGNIFICENT SEVEN IN OKLAHOMA'S WINTER WHEAT PRODUCTION REGION.

Case R. Medlin, Extension Weed Specialist, Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK 74078.

The most problematic weed problems in Oklahoma's wheat producing region are a group of winter annual grasses, including cheat (*Bromus secalinus*), downy brome (*B. tectorum*), rescuegrass (*B. catharticus*), feral rye (*Secale cereale*), Italian ryegrass (*Lolium multiflorum*), jointed goatgrass (*Aegilops cylindrica*), and wild oat (*Avena fatua*). The use of sulfosulfuron since the late 1990's has improved control of cheat in western Oklahoma, the major wheat producing region of the state. However, sulfosulfuron has marginal activity at best on most of these other weed species. With the use of Clearfield Wheat production systems marketed first in 2002, Oklahoma producers can now effectively manage these other weed problems in wheat.

Experiments were established on farmer cooperator fields in the fall of 2001 and 2002 to evaluate several herbicides for control of cheat, Italian ryegrass, feral rye, and jointed goatgrass in winter wheat. The wheat variety used to plant these trials was an experimental population of imidazolinone-tolerant hard red winter wheat provided by Dr. B. Carver of Oklahoma State University. The experiment design at each location was a randomized complete block with 12 by 30 ft or 10 by 25 ft plots and four replicates. Treatments included chlorsulfuron + metsulfuron in a 5:1 ratio (Finesse) applied PRE at 0.38 oz ai/acre, sulfosulfuron (MON 37500 or Maverick) applied POST at 0.5 oz/acre, flucarbazone-sodium (MKH 6562 or Everest) applied POST at 0.43 oz/acre, imazamox (Beyond) applied POST at 0.5 and 0.63 oz/acre, imazapic (Plateau) applied POST at 1 and 1.25 oz/acre, mesosulfuron-methyl + mefenpyr-diethyl in a 1:2 ratio (AE F130060 + AE F107892 or Osprey) applied POST at 0.21 + 0.42 oz/acre, diclofop (Hoelon 3EC) applied POST at 12 oz/acre and an untreated check. POST treatments were applied in the fall (October-November), winter (January-February), and/or spring (March) months. All label recommended additives were included with the POST treatments. Weed control was visually estimated prior to harvest and grain yield, moisture and dockage due to weed seed were determined by harvesting at maturity.

All treatments except chlorsulfuron + metsulfuron applied PRE controlled cheat at least 95%. Chlorsulfuron + metsulfuron, which is labeled for cheat suppression, suppressed cheat less than 45%. Sulfosulfuron and flucarbazone-sodium controlled cheat at least 95%, but were ineffective on feral rye, and jointed goatgrass regardless of application timing. Imazamox controlled cheat and jointed goatgrass at least 99% regardless of application timing or rate. Control of jointed goatgrass with imazamox decreased dockage (due to weed seed in the harvested grain) from over 7% to less than 0.4% except with the winter applications which still had approximately 1% weed seed in the harvested grain. Imazamox controlled feral rye approximately 80 to 85% when applied in the winter months, but control was between 85% and 99% when the herbicide was fall or spring applied. The fall and spring imazamox treatments decreased dockage in the harvested grain (due to feral rye seed) from 13.3% to 3% or less at one location and from 17.3% to less than 2% at the other experiment location. Metsulfuron + chlorsulfuron applied PRE and followed with an activating rainfall controlled Italian ryegrass 85% at harvest, however, without a timely rainfall after application control was 0%. Fall applications of imazamox, imazapic, or mesosulfuron-methyl + mefenpyr-diethyl consistently controlled Italian ryegrass better than winter or spring applications. This control differential translated into an average 17 bushel/acre yield advantage when these herbicides were applied in the fall rather than in the winter or spring months.

EFFECTS OF ATRAZINE RATES ON WHEAT DOUBLE CROPPED FOR FORAGE IN CONTINUOUS CORN. Randall S. Currie, Research Weed Scientist, K-State Southwest Research-Extension Center, 4500 East Mary Street, Garden City, KS 67846.

The study was established in a 2 by 3 factorial arrangement of cover crop (with and without) and atrazine rate (0, 0.75 and 1.5 lb/a). A wheat forage crop was inserted between corn crops by planting wheat after corn harvest in October. A 1-inch irrigation was applied, to ensure uniform emergence if sufficient rain was not received. This was done as an adjunct to a study measuring the impact of wheat as a killed cover crop on soil water use and weed control. (See proceedings Weed Science. Society of America 41:132). Wheat was allowed to grow until the late boot stage, at which point all aboveground wheat biomass was harvested from 1 foot of row. The experiment was repeated at three separate locations from 1999 and 2003, and it was further replicated by re-imposing the treatments on the same plots in three successive years. There were a total of nine location-year combinations. Prior to beginning of these studies, each location was fallowed one year There were 3 plots/replicate and 5 replicates. When treatments were re-imposed, a full season of corn at the various levels of atrazine had been grown at each location. When treatments were re-imposed a second time, two full seasons of corn had been grown. The fallow period prior to the first wheat planting consistently produced higher forage yields. Planting wheat back into a single season of corn stubble reduced forage yield 2 out of 3 times. There was no statistically significant impact of prior atrazine treatment on wheat forage yield. Planting wheat into corn stubble from two seasons also reduced yield compared to fallow history in all cases. It is of note that at no time was a reduction in forage yield associated with any prior atrazine use history. Furthermore, previous use of the 0.75 lb/a atrazine rate may have elevated yield, although no explanation of this effect is offered here. Nonetheless, the results clearly showed that yield was not depressed by prior atrazine use history. Severe injury can occur from residual atrazine to wheat planted into sandy soils or on other soils without sufficient rainfall or irrigation. It should also be noted that it is a violation of federal law to double crop wheat into corn and sorghum stubble that have been treated with 1 lb/a of atrazine. The work presented here is for the sole purpose of documenting crop response. It is not intended as an endorsement of cropping practices that ignore label restriction. The reader is advised that, unless an exemption is obtained, federal and state laws require pesticide usage to be in accordance with the label. This includes any pre-harvest and/or post-harvest intervals that are contained on the label.

SIMULATED DRIFT OF GLYPHOSATE AND IMAZAMOX ON WINTER WHEAT. Zach A. Deeds, Dallas E. Peterson, Kassim Al-Khatib, and Phillip W. Stahlman, Graduate Research Assistant, and Professors, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Off-target movement, or drift, of herbicides can have a significant influence on the growth and development of winter wheat. Glyphosate and imazamox are common pre-plant burndown and postemergence herbicides that may be applied to fields in close proximity to wheat in the spring. Consequently, dirft of these herbicides onto wheat at critical stages of growth and development could cause serious injury and yield reductions. Field research was conducted at Hays and Manhattan, Kansas in 2002 and 2003 to determine the effects of simulated drift of glyphosate and imazamox on winter wheat.

Glyphosate and imazamox at 1/100X, 1/33X, 1/10X, and 1/3X of typical field use rates were applied to wheat in the early jointing or the early flower stages of growth. The 1X use rates of glyphosate and imazamox were 840 g ae/ha and 35 g ai/ha, respectively. All treatments were applied at 187 L/ha spray volume and with the recommended adjuvant rates. Crop injury was evaluated at 4 weeks after treatment, and wheat was harvested at the end of the season to determine yields and the viability of the harvested seed.

A significant interaction occurred among the locations and years, probably due to differences in precipitation amounts and distribution through the growing season. Wheat injury and yield loss increased as herbicide rate was increased, with minimal effect from either herbicide at the 1/100X rate, and near complete kill and yield loss of wheat from both herbicides applied at the 1/3X rate, regardless of application stage. The greatest differences between herbicides and treatment stages occurred at the 1/33 and 1/10X rates. In general, wheat injury and yield reduction was greater from glyphosate than imazamox. Wheat injury and yield loss generally was greater from herbicide treatment at the jointing stage than at the heading stage of wheat development. Drought stress on the wheat at Hays in 2002 appeared to reduce the effect of the herbicide treatments on the wheat compared to the other year and location. Germination tests on the harvested grain sample suggested that the viability of the wheat seed was not reduced if plants survived the herbicide treatment and produced a harvestable crop.

OAT RESPONSE TO MESOTRIONE. Eric E. Dvorak and Kirk A. Howatt, Graduate Research Assistant and Assistant Professor, North Dakota State University, Fargo, 58105.

Field research was conducted at two locations in eastern North Dakota in 2002 and 2003 to evaluate oat response to mesotrione applied at varying rates and timings. Mesotrione at 26, 52, 105, 210 or 420 g ha^{-1} were applied to two or four leaf oat in the first experiment, and at 105 g ha^{-1} to pre emergence, spike, 1, 2, 3, 4, or 5 leaf oat in the second experiment. Each post emergence application included petroleum oil at 1% v/v and 28% urea and ammonium nitrate solution at 2.5% v/v. Field trials were established in a randomized complete block design with four replicates. Oat injury was evaluated during the growing season and harvested at maturity. Harvested seed weight was used to calculate yield, and germination was evaluated using a rolled towel test. Oat injury increased as mesotrione rate increased. Treatments receiving 210 or 420 g ha^{-1} exhibited 25 and 45% injury 14 days after application (DAA), respectively. In the rate study, two leaf oat exhibited less injury than four leaf oat. In the timing study, oat treated between three and five leaf exhibited higher injury than oat treated prior to the three leaf stage, and injury was less than 5% for oat treated prior to three leaf and up to 15% at the five leaf stage 14 DAA. However, yield and germination were not different from untreated oat.

EFFECT OF APPLICATION TIMING ON WILD OAT CONTROL WITH EIGHT HERBICIDES.

Craig M. Alford[1]*, Roger M. Hybner[2] and Stephen D. Miller[1], Graduate Research Associate, Director and Professor, [1]Department of Plant Sciences and [2]Sheridan Research and Extension Center, University of Wyoming, Laramie, WY 82071.

Wild oats are a serious weed problem for small grain producers throughout the world. Wild oats reduce yields through competition as well as contaminating harvested grain. In recent years there have been some new herbicides developed for control of wild oats in spring wheat. The development of imi-tolerant spring wheat has also provided an additional option for control of wild oat. There is limited information available that provides direct comparisons between the older standards and the recently developed products.

Studies were conducted at the University of Wyoming Research and Extension Center, Sheridan from 2000 to 2003 to investigate the effect of herbicide and application timing on wild oat control and wheat yields. Clodinafop, diclofop, difenzoquat, fenoxaprop, flucarbazone, imazamethabenz, imazamox, and tralkoxydim were applied to spring wheat at the 3 and 5-leaf growth stage, using recommended use rates and additives for each herbicide. All treatments were applied with a pressurized backpack sprayer delivering 187 L ha^{-1} at 276 kpa. All treatments were replicated 3 times and set in a randomized complete block design. Crop injury, stand reduction and wild oat control was visually evaluated 19 to 62 days after the 5 leaf application, wheat height was also measured at this time. Wheat yields were collected in all years except 2002. Flucarbazone was the only herbicide to cause crop injury, but it was variable from year to year. The most severe injury was observed in 2001, which resulted in stunted wheat in the flucarbazone treatments particularly with the 5 leaf application. Other than this instance, height was not affected by herbicide or application timing. No stand reduction was observed with any treatment. Clodinafop and flucarbazone were the only treatments to consistently provide greater than 90% wild oat control regardless of application timing. All treatments except imazamox provided greater wild oat control at the 3-leaf compared to the 5-leaf timing. The 3-leaf application timing generally produced the largest wheat yields however there were no yield differences between herbicide treatments.

MESOSULFURON PLUS ADJUVANTS FOR USE IN SPRING WHEAT. Kevin B. Thorsness*, Dean W. Maruska, Jack D. Otta, Michael C. Smith, and Mary D. Paulsgrove, Technical Service and Field Development Representatives, Bayer CropScience, Research Triangle Park, NC 27709.

Mesosulfuron-methyl plus mefenpyr-diethyl is a new a postemergence wild oat herbicide that is being developed by Bayer CropScience. It will be formulated as a 2 WDG and will be marketed as SILVERADO™ Wild Oat Herbicide. Mesosulfuron-methyl will provide control of wild oat including ACC-ase resistant biotypes in spring wheat and durum wheat. An adjuvant system will be required with mesosulfuron-methyl for effective wild oat control. Rapid soil degradation of mesosulfuron-methyl will allow planting of wheat and barley 7 days after application. Sunflower, soybean, lentils, dry beans and peas can be planted 90 days after an application of mesosulfuron-methyl and sugarbeet, potato and canola can be planted after a 10-month interval.

Adjuvant screening trials were conducted in a greenhouse to identify the most effective adjuvants for use with mesosulfuron-methyl. Based on these results, the most effective adjuvants were further evaluated in field trials at multiple sites. Field trials were established to determine the best adjuvant system for controlling wild oat with mesosulfuron-methyl alone or tank mixed with broadleaf herbicides in spring wheat. Adjuvant classes tested were; surfactants, silicone surfactants, crop oil concentrates, basic blends, methylated seed oils, methylated seed oil basic blends, and methylated seed oils with organosilicone surfactants. Crop tolerance and wild oat efficacy were evaluated for all treatments.

Percent visual crop injury was acceptable with mesosulfuron-methyl, regardless of the adjuvant system. However, percent visual wild oat control with mesosulfuron-methyl was influenced by adjuvant and adjuvant class. In general, methylated seed oil or basic blend adjuvants combined with mesosulfuron-methyl provided the best control of wild oat. Based on these results mesosulfuron-methyl is adjuvant and adjuvant class sensitive. Therefore an approved list of adjuvants that can be utilized with mesosulfuron-methyl will be developed.

Mesosulfuron-methyl will provide growers with an important tool for wild oat management including ACC-ase resistant wild oat in spring wheat and durum wheat.

WEED CONTROL OPTIONS WITH MESOSULFURON IN SPRING WHEAT. Dean W. Maruska, Kevin B. Thorsness, Jack D. Otta, Michael C. Smith, and Mary D. Paulsgrove, Field Development Representative, Bayer CropScience, Research Triangle Park, NC 27709.

SILVERADO™ Wild Oat herbicide is a new specially formulated herbicide containing the active ingredient mesosulfuron-methyl in a 2 WDG formulation with a highly effective wheat safener, mefenpyr to control wild oat in spring and durum wheat. Mesosulfuron-methyl is an inhibitor of acetolactate synthase (ALS) and will control both susceptible and ACC-ace resistant wild oat and some broadleaf weeds. Rapid soil degradation of mesosulfuron will allow many important follow-crops to be planted within 90 days of application and all crops may be rotated within a maximum of 12 months following a SILVERADO™ Wild Oat herbicide application.

2.5 – 3.0 g ai /ha of mesosulfuron were applied using the 2 WDG SILVERADO™ Wild Oat herbicide formulation with 1.75 L/HA methylated seed oil (MSO) at 1 leaf to 2 tiller wild oat stage of growth. Additionally, various broadleaf herbicides containing active ingredients MCPA ester, bromoxynil, thifensulfuron, tribenuron, clopyralid or fluroxypyr were tankmixed with the SILVERADO™ Wild Oat herbicide plus MSO or basic blend adjuvants to evaluate crop tolerance, broadleaf weed control and the potential for wild oat antagonism.

Results show that SILVERADO™ Wild Oat herbicide alone or in combination with the commonly available broadleaf herbicides tested has good crop tolerance, excellent wild oat control and a wide spectrum of broadleaf control options. SILVERADO™ Wild Oat herbicide will have an important fit in integrated weed control management systems in cereals because of broad crop rotational choices with excellent application flexibility and efficacy, notably the control of susceptible and ACC-ase resistant wild oat.

NITROGEN, ADJUVANT, AND APPLICATION TIMING EFFECTS ON IMAZAMOX EFFICACY IN WHEAT. Patrick W. Geier, Phillip W. Stahlman, and John C. Frihauf, Assistant Scientist, Professor, and Assistant Scientist, Kansas State University Agricultural Research Center, Hays, KS 67601.

Field experiments conducted near Hays and Colby, KS in 2002-2003 evaluated the effects of 28% urea-ammonium nitrate (UAN), adjuvants, and application timing on imazamox efficacy in winter wheat. In one experiment, no application timing by herbicide treatment interaction occurred at Hays or Colby, nor was the main effect of herbicide treatment (UAN rate) significant at Hays. Fall-postemergence (fall-POST) treatments were 28 to 37% more efficacious on blue mustard, downy brome, and jointed goatgrass than spring-postemergence (spring-POST) treatments at Hays. Flixweed control was 82% regardless of application timing. At Colby, jointed goatgrass was controlled better with fall-POST treatments compared to spring-POST treatments, though differences between timings decreased as the season progressed. Imazamox controlled jointed goatgrass better early in the season when UAN rates were 5% v/v or more compared to 1% v/v, however no differences were observed later in the season. Yields did not differ between treated and nontreated wheat at Colby. Wheat treated fall-POST or spring-POST at Hays yielded 51 and 28% more grain than nontreated wheat.

In a second experiment, imazamox at 35 or 53 g/ha controlled flixweed and jointed goatgrass 94% or more regardless of adjuvant, rate, or UAN concentration at Hays. Blue mustard and downy brome control was variable (59 to 91%) and no clear trends were evident. Jointed goatgrass control at Colby was 81 to 100%; generally, control was best with imazamox at 53 g/ha, when methylated seed oil was the adjuvant, or when Quad 7 rates exceeded 0.25% v/v. Yields did not differ between treated and nontreated wheat at Colby, however, herbicide-treated wheat at Hays yielded 21 to 34 bu/A more than nontreated wheat.

IMI-TOLERANT WINTER WHEAT RESPONSE TO IMAZAMOX. Stephen D. Miller*, John C. Frihauf and Craig M. Alford, Professor, former Graduate Research Assistant and Research Scientist, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Feral rye infestations have increased dramatically in winter wheat – fallow systems in southeastern Wyoming the last ten years and currently cost growers 0.5 to 0.75 million dollars annually. The imi-tolerant winter wheat system is a new technology which allows selective control of feral rye in this cropping system. However, cultivar response to different imazamox rates, additives and timings of application has not been investigated.

Weed free field studies were conducted under sprinkler irrigation at the Research and Extension Center, Torrington, WY in 2001-02 and 2002-03 to evaluate the response of five imidazolinone tolerant winter wheat cultivars to 0.048 and 0.096 lb/A imazamox applied with non-ionic surfactant or methylated seed oil in the early fall, late fall or early spring. The experiment was laid out as a split-plot factorial arrangement of rate, additive, and timing. Herbicide treatments were applied with a CO_2 pressurized knapsack sprayer delivering 20 gpa at 40 psi. Data collected included injury, heads/m, seed/head, yield and 200 seed weight.

Winter wheat injury with imazamox treatments was greater in 2002 than 2003. Environmental conditions differed between years with 2001-02 being cooler and drier than 2002-03 at all three application timings. However, similar trends were observed both years so the data was combined over years. Winter wheat injury was greater with early fall compared to late fall or early spring applications, with 0.096 compared to 0.048 lb/A, and with methylated seed oil compared to X-77. Yield reductions with these factors were approximately half of the early season injury ratings indicating plants partially recovered by harvest. Yield reductions were related to heads/m (r^2=0.91) but not seed/head or 200 seed weight. Fidel was the most sensitive wheat cultivar to imazamox applications and Above and AP-502CL the most tolerant.

BROME CONTROL IN WINTER WHEAT WITH PROPOXYCARBAZONE. Kevin K Watteyne, Jack D. Otta, Greg Hudec, Kevin B. Thorsness, George Simkins, Amy Wyman and Shane S. Hand, Bayer CropScience RTP, NC 27709.

Propoxycarbazone herbicide is a new postemergence herbicide being developed by Bayer CropScience for weed control in winter wheat. Propoxycarbazone herbicide is comprised of the active ingredient propoxycarbazone-sodium. This herbicide acts as an inhibitor of acetolactate synthase (ALS) and is a member of the sulfonylaminocarbonyl triazolinone class of chemistry. Propoxycarbazone-sodium will control many important grass weeds in winter wheat and is highly active on downy brome, cheat, Japanese brome, and soft chess as well as a multitude of broadleaf weeds such as wild mustard and tumble mustard. Propoxycarbazone herbicide exhibits excellent winter wheat tolerance at 30 to 45 g ai /ha.

In field experiments in North America, propoxycarbazone-sodium controlled downy brome cheat, Japanese brome, soft chess, wild canarygrass, and windgrass as well as wild mustard, Tansy mustard, and blue mustard. Propoxycarbazone herbicide is applied to grass weeds up to 2-tillers in size and broadleaf weeds up to 1-2 leaf in size. Applications of Propoxycarbazone herbicide must include a tankmix partner of a non-ionic surfactant at a rate of 0.25-0.5% v/v.

Propoxycarbazone herbicide has a very favorable ecological, ecotoxicological and environmental profile with low acute mammalian toxicity and no genotoxic, mutagenic or oncogenic properties noted. Microbial degradation is the primary degradation pathway of propoxycarbazone-sodium in the environment. Propoxycarbazone-sodium offers a flexible recropping profile to succeeding crops. Excellent control of ACC-ase resistant wild oat (*Avena fatua* L.) biotypes have been attained with propoxycarbazone herbicide in field trials.

The low use-rate, excellent weed control and crop safety combined with very favorable toxicological, ecotoxicological and environmental properties will make this product a valuable new tool for winter wheat farmers. Propoxycarbazone herbicide will have the common name “Olympus”, with expected registration early in 2004.

EVALUATION OF DISCOVER® NG FOR POSTEMERGENCE WEED CONTROL IN WHEAT. Peter C. Forster and Donald J. Porter, Syngenta Crop Protection, Greensboro, NC 27419.

Discover NG is a new formulation of clodinafop-propargyl with a novel built-in adjuvant system that has been developed for postemergenge annual grass control in wheat. In field experiments conducted during 2002 and 2003, Discover NG at 56g ai/ha provided excellent control of wild oats (*Avena fatua*), green foxtail (*Setaria viridis*), yellow foxtail (*Setaria glauca*), barnyardgrass (*Echinochloa crus-galli*) and volunteer corn (*Zea mays*). At 70g ai/ha, Discover NG provided effective control of giant foxtail (*Setaria faberi*), Persian darnel (*Lolium persicum*) and Italian ryegrass (*Lolium multiflorum*). Discover NG provided consistent grass control when applied with ground or aerial application equipment and when evaluated at several spray volumes. Discover NG was extensively evaluated in tank mixture with a number of broadleaf herbicide combinations for one-pass annual grass and broadleaf weed control. Spring and winter wheat varieties exhibited excellent tolerance to Discover NG. U.S. EPA registration for Discover NG has been granted.

CONTROL OF JOINTED GOATGRASS USING BEST MANAGEMENT PRACTICES. Anthony D. White and Phillip W. Stahlman, Extension Coordinator, National Jointed Goatgrass Research Program and Research Weed Scientist, Kansas State University, Agricultural Research Center-Hays, 1232 240th Ave., Hays, KS 67601.

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 appears to spread every year. Jointed goatgrass costs producers $45 million annually due to reduced grain yields – commonly a 25% to 50% loss - and increased dockage at the grain terminal. An additional $100 million is estimated to be lost in reduced land value due to this troublesome weed.

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 information regarding jointed goatgrass biology and management has been discovered 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 dramatically improved the Best Management Practices (BMPs) for controlling jointed goatgrass.

Although crop rotation is perhaps the most important single component in managing jointed goatgrass, other management components can help minimize competition with winter wheat. Combining multiple cultural practices, including crop rotation, competitive wheat varieties, and proper fertilizer placement, into a integrated jointed goatgrass management program can further improve control compared to using only single components. Although jointed goatgrass competition with winter wheat cannot be eliminated through any combination of practices reviewed here, clearly the proper combination of these factors can limit the growth and seed production of jointed goatgrass. Scientists continue to further examine the best management practices to effectively control jointed goatgrass.

Growers using these BMPs will have cleaner wheat fields, reduced dockage, and better yields. Keep in mind that certain strategies may not be appropriate in all regions. Additional information regarding the management and biology of jointed goatgrass or other aspects of this national research initiative can be found online at www.jointedgoatgrass.org.

CLETHODIM FORMULATIONS IN OILSEED CROPS AND SUGARBEET. Richard K. Zollinger, Kirk A. Howatt, and Alan G. Dexter, Weed Scientists, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Field research was conducted in 2003 at several locations to evaluate efficacy of clethodim formulations applied alone or with broadleaf herbicides. All or some clethodim formulations, including Select (2 lb/gal), Arrow (2 lb/gal), V-10117 (1 lb/gal), V-10137 (1 lb/gal), and V10137 (1 lb/gal) were applied alone or with sugarbeet herbicides, alone on conventional canola, with glufosinate on Liberty Link canola, with glyphosate on Roundup Ready soybean, and with tribenuron on Express Resistant sunflower.

Select, V-10137, and V-10139 applied once alone with MSO adjuvant or four times at seven day intervals with desmedipham&phenmedipham + triflusulfuron + clopyralid + MSO adjuvant at 0.08 + 0.004 + 0.031 lb/A + 1.5% v/v (micro-rate) gave 100% control of foxtail millet, durum wheat, tame oat, and corn. However, MSO adjuvant cannot be used with conventional rates of sugarbeet herbicides two to four times higher than the micro-rate, due to the excessive risk of sugarbeet injury. Select and V-10139 without MSO applied in the last of three or in all three conventional rate applications gave 68 to 89% grass control. V-10137 without MSO applied in the last of three or in all three conventional rate applications gave 90 to 98% grass control, better than Select or V-10139 plus conventional rates without MSO but not as good as Select, V-10139 or V-10137 plus the micro-rate plus MSO. V-10137 without MSO gave 100% grass control when applied without other herbicides. These results suggest that V-10137 does not need MSO when used alone but including MSO would increase grass control from V-10137 when used in combination with other herbicides.

In conventional canola, by 30 DAT, Select, V-10117, and V-10137 formulations of clethodim at 1.5 oz/A plus PO or V-10137 without PO, gave 99% control of wheat and barley. However, speed of kill was faster with V-10137 without PO adjuvant. In Liberty Link canola, glufosinate at 6 oz/A plus ammonium sulfate (AMS) applied with Select, V-10117, V-10137, and V-10139 at 1 oz/A also gave 99% grass control at 28 DAT.

In Roundup Ready soybean, by 14 DAT, Select, Arrow, and V-10139 formulations of clethodim at 1.25 oz/A with or without nonionic surfactant (NIS) plus AMS applied alone or with glyphosate gave 99% volunteer corn and yellow foxtail control. V-10137 at 1.25 oz/A with no adjuvants provided 99% volunteer corn and yellow foxtail control but when applied with either PO or NIS alone or with AMS, yellow foxtail control was reduced to 70 to 85%. Initially, V-10137 without PO adjuvant produced a faster speed of kill but all treatments provided 99% grass control by 28 DAT.

In Express Resistant sunflower, tribenuron at 0.19 oz/A antagonized wheat and yellow foxtail control from Select, Arrow, V-10117, and V-10139 but not V-10137, applied at 1.5 oz/A. Grass control was reduced from 99% when clethodim formulations (except V-10137) were applied with PO to 50% to 80% when applied with tribenuron plus PO. V-10137 plus PO, or V-10137 plus tribenuron with or without PO gave 99%, 96%, and 92% grass control, respectively.

The results from clethodim formulations of V-10117 and V-10139 applied with PO in canola, soybean and sunflower suggest that control is similar to Select or Arrow plus PO applied at similar rates. However, V-10137 does not need oil adjuvant for grass control and can overcome tribenuron antagonism. Including an oil adjuvant with V-10137 may not increase grass control when used with tribenuron.

WEED CONTROL IN SULFONYLUREA-TOLERANT SUNFLOWER. Phillip W. Stahlman, John C. Frihauf, and Curtis R. Thompson, Research Weed Scientist, Assistant Scientist, and Extension Crops and Soils Specialist, Kansas State University, Agricultural Research Center, Hays, KS 67601 and Southwest Research-Extension Center, Garden City, KS 67846.

Three field experiments were conducted near Hays and Tribune, KS in 2003 to evaluate weed control in sulfonylurea (SU)-tolerant sunflower. One experiment evaluated weed control and crop tolerance to postemergence-applied tribenuron at four rates (0.125, 0.188, 0.25, and 0.5 oz ai/A) applied singly and sequentially at three sunflower growth stages (3- to 4-inch, 8- to 12-inch, and bud). At 47 days after treatment (DAT), no singly-applied tribenuron treatment controlled Palmer amaranth more than 58%. Most sequential tribenuron treatments were more effective than single applications; control ranged from 68 to 78% control at 62 DAT. Imazamox at 0.031 lb ai/A was no more effective on Palmer amaranth than tribenuron treatments. Tribenuron treatments applied at the 8- to 12-inch growth stage cause minor (3 to 4%) leaf chlorosis 5 DAT; the effect disappeared within a week. Imazamox applied at 3- to 4-inch or 8- to 12-inch growth stages caused 5 to 10% more chlorosis than tribenuron treatments. Plants recovered within 10 days. Tribenuron treatments did not stunt sunflower plant growth or reduce yield, whereas imazamox stunted growth by as much as 40% and reduced yield by as much as 57%. Clearly, the SU-tolerant line used in this study was not tolerant to imazamox.

A second experiment evaluated the effects of various adjuvants on the efficacy of tribenuron and crop tolerance. Generally, Palmer amaranth control increased as tribenuron rate increased, with the greater increase occurring between 0.125 and 0.25 oz/A compared to 0.25 and 0.5 oz/A. Only tribenuron at 0.5 oz/A plus Dyne-Amic at 4 pt/A exceeded 70% control. Dyne-Amic consistently enhanced tribenuron activity the most and Kinetic the least of the adjuvants tesed. Activator 90, MSO Concentrate, Premium Crop Oil Concentrate, and Liberate were intermediately in effectiveness. Several treatments caused ≤5% leaf chlorosis 5 to 7 DAT, but plants recovered within 7 days. Sunflower yields did not differ within herbicide treatments or between treated and non-treated sunflower.

In the third experiment, tribenuron was compared with sulfentrazone. Both herbicides controlled redroot pigweed and tumble pigweed 81 to 100% at 13 and 76 DAT. Redroot pigweed and tumble pigweed control improved as sulfentrazone rate increased with the largest increase occurring between 1.5 and 2.25 oz ai/A. Control was 10% higher when 0.125 oz/A tribenuron was applied following preemergence applications of sulfentrazone or ethalfluralin compared to tribenuron alone. Sulfentrazone at 1.5, 2.25, or 4.0 oz/A controlled kochia 95% or more, whereas control with tribenuron at 0.125 oz/A was 74%. Both herbicides controlled Russian thistle by 91 to 100%. Sulfentrazone at 4 oz/A caused 15% leaf chlorosis at 16 DAT but plants had recovered at 30 DAT. Tribenuron caused no injury and sunflower yields did not differ between treatments.

WHEAT YIELD RESPONSE TO WINTER ANNUAL WEED INTERFERENCE AND CROP STAND LOSS. Shawn P. Conley, Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211.

No-till production systems coupled with decreased use of soil residual herbicides has led to increased populations of winter annual weeds. Therefore, research was conducted to quantify the effect of winter annual weed interference and crop stand loss on soft red winter wheat yield and quality. The experimental design was a randomized complete block split-plot design with four replications. The main-plot effect consisted of weed-free versus weedy plots. The sub-plot effect was winter wheat stand loss treatments of 0, 20, 40, 60, 80, and 100%. Henbit or common chickweed interference did not affect test weight; however test weight decreased as percent stand loss increased. Henbit did not reduce crop yield at 18 plants m^{-2}, however at 82 and 155 plants m^{-2} crop yield was reduced 13 and 38%, respectively, whereas common chickweed reduced crop yield 28% at 169 plants m^{-2}. Yield estimates based on tiller or head number m^{-2} indicated that crop yield decreased linearly as stand loss increased. These results suggest that winter annual weed interference and crop stand loss may significantly impact soft red winter wheat grain yield and quality.

GLADIOLUS AND WEED RESPONSE TO FLUMIOXAZIN AND OTHER HERBICIDES. Robert J. Richardson and Bernard H. Zandstra, Michigan State University, East Lansing, MI 48824.

Few herbicide options are available for broadleaf weed control in gladiolus production. Flumioxazin is currently in development for preemergence (PRE) use in this cropping system. Therefore, field studies were conducted in 2002 and 2003 near Bronson, MI, to evaluate flumioxazin for use in gladiolus. In the first study, flumioxazin was compared to other PRE herbicides and an untreated control. Gladiolus injury was generally greatest with oxyfluorfen, clomazone, imazapic, or imazamox. Visible injury with other herbicides was low, although small necrotic leaf lesions were occasionally observed with some treatments. The number of flower stalks per plot, stalk height, and number of flowers per stalk did not differ between most treatments and the untreated control. Only pendimethalin controlled giant foxtail (*Setaria faberi* Herrm.) greater than 80% in both years. Control of common ragweed (*Ambrosia artemisiifolia* L.) was 80% or greater in both years with flumioxazin, mesotrione, halosulfuron, and linuron. Halosulfuron and sulfentrazone controlled yellow nutsedge (*Cyperus esculentus* L.) at least 70% in both years, but several herbicides did reduce the nutsedge population as compared to the untreated control. In the second study, flumioxazin was applied at four rates and in mixture with metolachlor. A comparison treatment of oryzalin plus isoxaben and an untreated control were also included. Gladiolus injury was greatest with 560 g ai/ha flumioxazin. Weed control was generally acceptable with flumioxazin at 140 g/ha or greater. Gladiolus height and the number of flowers per plant did not differ between flumioxazin rates and the control.

CONTROL OF VOLUNTEER HORSERADISH IN CORN PRODUCTION. Mark F. Rundle, S. Alan Walters, Ronald F. Krausz, and Bryan G. Young, Graduate Research Assistant, Assistant Professor, Researcher, and Associate Professor, Southern Illinois University, Carbondale, IL, 62901.

Volunteer horseradish (*Armoracia rusticana*) in rotational crops can serve as a host for verticillium wilt (*Verticillium dahliae*) which is a major production challenge in horseradish production. Control of volunteer horseradish in rotational crops is desirable to possibly reduce the inoculum levels of this pathogen. Greenhouse and field studies were conducted in 2002 and 2003 to determine the efficacy of various postemergence herbicides for control of volunteer horseradish in corn. In greenhouse studies, halosulfuron and 2,4-De provided 92% or greater control of horseradish at 21 days after treatment. Dicamba provided less control than halosulfuron and glyphosate provided less than 75% control of volunteer horseradish.

Herbicides were applied in field studies when volunteer horseradish was 15 and 30 cm in height in conventional till corn. Primisulfuron was not effective for control of volunteer horseradish (<63%) at 56 days after treatment, regardless of application timing. The efficacy of halosulfuron on volunteer horseradish was greatest when applied to 15 cm horseradish compared with 30 cm. Control of volunteer horseradish was the most consistent with 2,4-De and the level of control achieved was similar to or greater than using primisulfuron or halosulfuron. In 2003, applying 2,4-De at the later application timing increased control of volunteer horseradish. However, application timing was not significant for 2,4-De in 2002. The general ranking of herbicide efficacy on volunteer horseradish was 2,4-De>halosulfuron>primisulfuron.

EFFECT OF CRITICAL PERIOD OF COMPETITION AND NO SEED THRESHOLD WEED MANAGEMENT STRATEGIES IN A TRANSITIONAL VEGETABLE ORGANIC SYSTEM. Karen J. Amisi *, Douglas J. Doohan, Matthew D. Kleinhenz and Sally Miller, Graduate Research Assistant and Associate Professors, The Ohio State University/OARDC, Wooster, OH 44691.

Weed management is one of the biggest challenges faced by organic farmers. Frequently used weed management practices include tillage, crop rotation, living and plastic mulches, cover crops, smother crops, and slashing. To provide a more rationale approach, we investigated the use of two weed control strategies, Critical Period of Competition (CP) and No Seed Threshold (NST) for farmers transitioning from conventional to organic production. Field experiments were conducted in 2001, 2002, and 2003 at the Ohio Agricultural Research and Development Center in Wooster, OH. In 2001, a 4-year transitional organic rotation of wheat, clover, cabbage, and processing tomato was established in soil previously in a conventional corn/soybean/forage agronomic rotation. The experimental design was a split plot in a Randomized Complete Block Design with 4 replications. Main plots were soil amendments (none, raw dairy manure, composted dairy manure). Amendments were applied in spring at the rate of 101 kg N/ha and incorporated prior to planting. Subplots were weed control strategies; NST, where seedling weeds were removed weekly for the whole season and no weeds permitted to mature seeds in the field, and CP, where plots were kept weed-free only for the first 5-6 weeks of crop growth. Each crop had 6 main plots of 222 m^2 each and 24 subplots with an area of 56 m^2 each. The impact of weed management strategies was evaluated by counting emerged weed seedlings in tomato and cabbage plots, and by exhaustive germination in the greenhouse of weed seeds in soil samples taken from plots in early spring of each year. In 2001, emerged weed seedlings in cabbage and tomato plots and soil seed bank weed counts for broadleaf and total weeds indicated adequate homogeneity between plots. In 2002 and to a greater extent in 2003, there were more emerged weeds present in CP than in NST plots. The seeds in the soil seed bank decreased from 2002 to 2003 and the decline was greater in samples from NST plots than from CP plots. Specific conclusions about the effect of amendments on weed communities cannot be determined at this time.

CANADA THISTLE CONTROL IN A POTATO AND SPRING WHEAT ROTATION. Sudeep A. Mathew and Harlene H. Valenti, Graduate Research Assistant and Assistant Professor, North Dakota State University, Fargo, ND 58105.

Field experiments were conducted to identify the effects of low temperatures associated with herbicide treatment on Canada thistle control in a potato and spring wheat rotation. Fields were selected with a natural infestation of Canada thistle at North Dakota State University's agricultural research farm in Fargo. Treatments were arranged in a randomized complete block design with herbicide and application timing as treatments and five replicates. Glyphosate and dicamba plus diflufenzopyr were applied to Canada thistle after harvest regrowth following at three different temperature regimes. Plant densities following potato harvest were much lower when herbicides were applied compared to the wheat field due to harvest operations and physiological characteristics of regrowth. These low initial plant densities in the potato field resulted in increased Canada thistle populations 1 yr after treatment. The smallest Canada thistle increase of 11 plants/m^2 occurred 1 yr after glyphosate at 3.1 kg ae/ha was applied and compared to an average increase of 50 plants/m^2 in untreated plots. Freezing temperatures prior to herbicide application did not influence Canada thistle control. In the spring wheat field, dicamba plus diflufenzopyr at 350 plus 140 g ae/ha applied prior to a freeze eliminated all Canada thistle. A single freeze did not affect Canada thistle control 1 yr after herbicide treatment with an average plant reduction of 88% when treated prior to a freeze and 87% when herbicides were applied after a freeze. However, Canada thistle control 1 yr after treatment with herbicides applied following multiple freezes averaged 62% across treatments.

HERBICIDE COMBINATIONS FOR IRRIGATED POTATO. Harlene M. Hatterman-Valenti and Paul G. Mayland, Assistant Professor and Research Specialist, North Dakota State University, Fargo, ND 58105.

Field research was conducted at the Northern Plains Potato Growers Irrigation site near Tappen, ND during 2002 and 2003 to evaluate preemergence and postemergence rimsulfuron and new products either tank-mixed or applied sequentially for crop safety and weed control in Russet Burbank potato. The studies were conducted on a loamy sand soil with 1.8% organic matter and 7.6 pH. Seed pieces (2 oz.) were planted May 21, 2002 and May 12, 2003. Preemergence tank-mix treatments consisted of rimsulfuron and dimethenamid-P, flumioxazin, metribuzin, or sulftentrazone. Sequential treatments consisted of preemergence dimethenamid-P, flumioxazin, metribuzin, or sulftentrazone followed by rimsulfuron applied postemergence. One additional herbicide treatment consisted of rimsulfuron plus EPTC applied postemergence. Methylated seed oil was used with all postemergence applications. In addition, ammonium sulftate was added to rimsulfuron plus EPTC. Sprinkler irrigation was scheduled every three to four days following potato hilling. Machine harvest occurred October 2, 2002 and September 30, 2003.

Weed populations in the untreated control and border check areas were sufficient for meaningful weed control data only during 2002. Evaluations indicated that all treatments except rimsulfuron plus EPTC provided greater than 80% green foxtail, Palmer amaranth, and wild buckwheat control at 52 days after treatment during 2002. Treatments with flumioxazin caused approximately 10% potato injury accross years primarily as necrotic lesions near the stem base and plant stunting. Marketable yield of potato treated with flumioxazin followed by rimsulfuron during 2002 was the lowest at 255 cwt/A. This was significantly less than potato yield from preemergence tank-mix treatments and similar to the untreated. During 2003 the lowest marketable yield (364 cwt/A) occurred from potato treated with flumioxazin and rimsulfuron applied preemergence. This was only significantly less than potato yield from dimethenamid-P followed by rimsulfuron.

NEW HERBICIDES FOR EASTERN BLACK NIGHTSHADE CONTROL IN TOMATO.
Vijaikumar Pandian* and Bernard H. Zandstra, Research Assistant and Professor, Michigan State University, East Lansing MI 48824.

Eastern black nightshade (*Solanum ptycanthum* Dun.) (EBNS) is a serious problem in Michigan tomato production. It has shown variable response to different herbicides and there are few registered herbicides for control. Field studies were conducted in 2002 and 2003 to evaluate the efficacy of potential herbicides for EBNS control in tomato. The herbicides were applied as pre-transplant, post-transplant, post-emergence and post-directed applications. In pre-transplant applications, oxyfluorfen (0.28 kg/ha), sulfentrazone (0.34 kg/ha) and flumioxazin (0.05 kg /ha) gave at least 95% control of EBNS, with no crop injury or yield reduction in both years. In post-transplant applications, dimethenamid (1.1 kg/ha) and s-metolachlor (1.8 kg/ha) gave 100% control of EBNS, with no crop injury or yield reduction in both years. When the nightshade plants were about 15 cm in height, post-emergence and post-directed treatments were applied. In post-emergence applications, sulfentrazone (0.22 kg/ha) controlled EBNS 93% with yield reduction of 30% in 2002. However in 2003, sulfentrazone (0.22 kg/ha) gave 60% EBNS control with no crop injury or yield reduction. Similarly, sulfosulfuron (0.03 kg/ha) + NIS (0.5% V/V) gave 67% control in 2002, but in 2003 it failed to control EBNS and there was no yield reduction in either year. Post-emergence application of rimsulfuron (0.035 kg/ha) and halosulfuron (0.035 kg/ha) + NIS (0.5%V/V) had minimal effect on EBNS in both years and caused no significant yield reduction. Pyridate (1.01 kg /ha) post-emergence gave at least 60% control of EBNS in 2002 and 2003 with no crop injury or yield reduction. Post-directed applications of flumioxazin (0.05 kg ai/ha) +NIS (0.5 % v/v) gave 68% and 100% control of EBNS in 2002 and 2003, with slight crop injury of 14% in 2003 but there was no yield reduction in either year. Carfentrazone gave 80% and 100% control of EBNS as a post-directed application in 2002 and 2003 respectively. However, it caused 36% and 75% crop injury with yield reduction of 44% and 54% in 2002 and 2003 respectively.

2003 North Central Weed Science Society Proceedings 58:166.

THE INFLUENCE OF CEREAL RYE SURFACE RESIDUES AND STAKING ON EASTERN BLACK NIGHTSHADE COMPETITIVENESS WITH TOMATO. Abram Bicksler and John Masiunas, Graduate Research Assistant and Associate Professor, University of Illinois, Urbana, IL 61801.

Eastern black nightshade (*Solanum ptycanthum* Dun.) is a difficult weed to control in tomatoes (*Lycopersicon esculentum*). The two species have similar herbicide susceptibilities and growth habits. Eastern black nightshade can overtop tomatoes and the two species primarily compete for light. Previous research has indicated that cereal rye surface residues controlled eastern black nightshade. It might be possible to modify tomato producton systems to make the crop more competitive with nightshade. The objective of our research was to evaluate a rye cover crop and staking as techniques to increase the competitiveness of tomatoes with nightshade. The rye cover crop inhibited tomato and nightshade growth similarly, especially in wetter areas of the field. Tomato yields were also substantially reduced in the cover crop treatment compared to bare ground. This growth and yield inhibition was due to soil compaction. Staking raised the tomato canopy over the nightshade and made the tomatoes for competitive for light. PAR levels at the tomato canopy and tomato yields were greater in the staked plots than in the nonstaked plots. Staking fresh market tomatoes may be one way to increase competitiveness and thus yield in areas where eastern black nightshade is difficult to control.

FLAME CONTROL FOR WEED MANAGEMENT IN CABBAGE AND TOMATO. Annette L. Wszelaki and Douglas J. Doohan, Postdoctoral Researcher and Associate Professor, Department of Horticulture and Crop Science, The Ohio State University, Ohio Agricultural Research and Development Center, 1680 Madison Ave., Wooster, OH 44691

In the spring of 2002, a field trial was established to control weeds safely, effectively, and economically in vegetable crops, by employing a flame weeder. Composted dairy manure (5 tons/A), bedded on sawdust and straw, and dairy manure (10 tons/A) were broadcast and incorporated into the field prior to planting in both years. The field was cultivated and beds prepared on one-half of the field on 28 May, 2002 and 20 June, 2003. 'Peto 696' tomato and 'Bravo' cabbage seeds were hot water treated and sown in mid-April of both years into 288-cell plug trays containing organic potting mix (#423, Paygro Co., South Charleston, OH) amended with Bradfield Gold 3-1-5 (Bradfield Industries, Inc., Springfield, MO) at a rate of ~300 g/m^3. On 29 May, 2002 and 20 June, 2003 seedlings were transplanted 40 cm apart into rows 9 m long on 1.5 m centers, half on raised beds and half on flat ground. On 20 June, 2002 at 10:30 AM (28.3 ºC, RH 56.6%, wind from the SSE, wind speed: 1.2 kph (vector), 2.3 kph (scalar)) and 5:00 PM (31.4 ºC, RH 36.1%, wind from SSE, wind speed: 2.5 kph (vector), 3.3 kph (scalar)) and 21 July, 2003 at 10:00 AM (21.0 ºC, RH 97.8%, wind from the SSE, wind speed: 1.8 kph (vector), 2.2 kph (scalar)) tomato and cabbage transplants were flamed with a Red Dragon 8-burner row crop flamer (Flame Engineering, Inc., LaCrosse, KS). Burners were arranged in a staggered crossfire pattern, set at a 60º angle (from horizontal), 10 cm from the crop and a pressure of 30 psi. Varying tractor speeds were used: 0 kph (unflamed), 4 kph, 8 kph, and 12 kph (2002 only). Plant injury due to flaming (% versus control) was evaluated 5 and 15 (2003) or 20 (2002) days after flaming (DAF). Weed control was evaluated 5, 20, 30, 40, and 50 DAF in 2002, and 5 and 15 DAF in 2003. At harvest, head traits were evaluated in the cabbage and diseases and disorders evaluated in the tomatoes that were flamed in the morning. Yield was calculated for both crops.

In 2002, the morning flaming treatments caused more injury (average ~10-40%) to cabbage and tomatoes than the afternoon flaming (average 2-4%). In both years, cabbage plants were more severely affected than tomato plants. All flaming treatments damaged the cabbage plants more than the control, with the 4 kph treatment causing more injury (~60%) than the 8 (~30%) or 12 (~5%) kph treatments, after 5 DAF. However, by 15 (2003) or 20 (2002) DAF, there was no evidence of injury in any treatment. In the morning flaming of tomato, damage was greater on raised beds than flat ground and greater in the 4 and 8 kph treatments than the unflamed and 12 kph treatments after 5 DAF. After 15 or 20 DAF, there was no sign of injury on any tomato plants. Afternoon flaming in 2002, in either crop, caused little injury (<5%), but controlled weeds much less effectively than morning flaming.

In all cases, any flaming speed provided greater weed control than the unflamed, unweeded control. In 2002, after 5 DAF, weed control in tomato was most effective in the 4 and 8 kph treatments, with ≥ 90% and ~80% control, respectively. In cabbage, from 20-50 d after flaming in 2002, the 4 kph treatment provided better control than all other treatments, with nearly 70% control versus the unflamed, unweeded treatment on both bed types, even at 50 d. Results were similar for tomato, though the 4 kph, raised bed combination was more effective in controlling weeds than flat ground, as the 4 kph-raised bed treatment had 70% weed control at 50 d, while the 4 kph-flat ground treatment was no different than the control. In 2003, after 5 d, the 4 kph treatment was most effective in tomato with >70% control in both bed types. However, after 15 d, control in the 4 kph treatment was reduced to ~20%. In cabbage, weed control was generally more effective on raised beds versus flat ground, though, due to the extremely wet conditions in 2003, weed control was not sustained as in 2002. In both years, grasses and succulent weeds were harder to control than broadleaf weeds.

Regarding tomato fruit quality, in both years, flaming reduced the incidence of blossom end rot. Yields were greater in the slower speed flaming treatments than the weedy control. In cabbage, larger heads and higher yields were found with the 4 kph flaming treatment.

2003 North Central Weed Science Proceedings 58:168.

COMPARING WEED COMMUNITIES ON ORGANIC AND CONVENTIONAL TOMATO FARMS ACROSS OHIO. Annette L. Wszelaki and Douglas J. Doohan, Postdoctoral Researcher and Associate Professor, Department of Horticulture and Crop Science, The Ohio State University, Ohio Agricultural Research and Development Center, 1680 Madison Ave., Wooster, OH 44691

Organic farmers contend that their greatest challenge is managing weeds. Accurate data has not been available on the specific weed problems experienced by organic farmers in Ohio. Moreover, there is little evidence in the scientific literature documenting the weed species and composition that organic farmers are trying to control versus their conventional counterparts. In the summer of 2002 and 2003 and fall of 2002, a survey comparing the weed communities found in organic and conventional farms was conducted across Ohio to fill in this knowledge gap.

The survey consisted of 40 farms (20 organic farms, paired with 20 neighboring conventional farms) and encompassed 24 counties around the state. Tomato fields were located and mapped using a GPS system. In 2002, an initial weed survey was conducted in July and a second survey was conducted in late September- early October. In 2003, the survey was continued in late July-mid-August. In each field, emerged weeds were sampled in twenty 0.25 m^2 sampling areas located along an inverted 'W' pattern throughout the field. Weeds were identified, counted, and mapped according to their occurrence and related landscape features.

The data were summarized using several quantitative measurements, including frequency, field uniformity, and density. Combining all three of these measurements, a single value, the relative abundance of the species, was calculated: Relative abundance = (frequency of a particular species/sum of frequency values for all species) + (uniformity of a particular species/sum of uniformity values for all species) + (density of a particular species/sum of density values for all species). This measurement was used to rank the species, according to their overall occurrence.

Seventy-five different weed species were found in this survey. Regardless of season or farm type, purslane had the highest relative abundance of surveyed species. However, pigweed appeared most frequently, occurring on 34 out of the 40 farms. Purslane was also the most uniform of the weeds overall, while quackgrass had the highest density of all the weeds (> 10 shoots/m^2). On the organic farms, in the summer, quackgrass had the highest relative abundance, while in the fall, quackgrass and foxtail had the highest relative abundance. However, barnyardgrass appeared most frequently (18 out of the 20 organic farms) and was the most uniform species in the summer, while foxtail was the most frequently occurring and uniform species in the fall. On the conventional farms in the summer, purslane had the highest relative abundance. Barnyardgrass and pigweed were the most frequently appearing weeds, occurring on 14 out of the 20 conventional farms. In the fall, purslane again had the highest relative abundance among the weeds on the conventional farms, followed by lambsquarters and chickweed.

In general, the weed communities were more diverse on the organic farms than on the conventional farms. Both farm types had more species in the summer than the fall. Thirty-two weed species were common to all seasons and farm types. The organic farms had 24 species of weeds that did not appear on the conventional farms, though only 8 of these appeared on more than one farm. Ten species found on the conventional farms were not found on the organic farms, although 40% of these were found on more than one farm. The results of this survey confirm that grasses tend to be more of a problem on organic farms, with the top two weeds being grasses in both the summer and fall, while broadleaves are more problematic on conventional farms, as only one grass made the top five weeds in each season on the conventional farms.

PERIOD THRESHOLD WEED MANAGEMENT EFFECTS ON SOIL WEED SEED BANK DYNAMICS IN A TOMATO ROTATION. Carlos D. Mayén and Stephen C. Weller, Graduate Research Assistant and Professor, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47906.

A 3 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 and a Roundup Ready soybean rotation. Soil management techniques studied were conventional tillage, no till and winter rye cover crop. Weed management involved either a threshold based program or a zero threshold program (no weed seed production). The seed bank composition was determined each year through the greenhouse germination method of soil sampled early in the spring. After 2 years of cropping, several patterns were observed in the soil seed bank. Crop had a major effect on the amount of giant foxtail and prickly sida seeds in the soil. Generally, seed banks increased following a tomato cropping season and tended to decrease following a soybean cropping season. An exception occurred in 2002 when soybeans were planted to rye cover crop mulch. Canopy closure was never attained and there was high foxtail seed production that enriched the seed bank. The effect of weed control intensity on the seed bank depended on the crop. For both crops, adoption of the zero threshold program resulted in an exponential decay of the seed bank. When period thresholds were adopted for weed control, the seed bank increased after following tomatoes or decreased after following a soybean crop. Regarding yields in the plots, after 1 rotation, an increase in soil weed seed bank did not affect yield in a competitive crop (soybean versus tomato).

RESPONSE OF TOMATOES, SNAP BEANS AND MUSKMELON TO HALOSULFURON. Carlos D. Mayén and Stephen C. Weller, Graduate Research Assistant and Professor, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907-2010.

Studies were conducted in the field to determine the response of tomato '611', muskmelon 'Eclipse', and snap beans 'Bromo' to pre-emergent and post-emergent applications of halosulfuron-methyl. Halosulfuron-methyl was applied pre emergent in combination with the standard soil applied herbicide either 2 weeks prior to planting or immediately prior to planting or applied postemergent 4 weeks after the soil applications. The standard was metolachlor in tomatoes and snap beans, and clomazone plus ethalfluralin in muskmelon. There were two pre-emergent rates of halosulfuron-methyl of 14 and 28 g/Ha and three post emergence rates of 14, 18 and 28 g/Ha for tomatoes, and two preemergent and two postemergent rates of 14 and 18 g/Ha for muskmelon and snap beans. A randomized complete block plot design with 4 replications was used. As a 7 day, pre-emergent application, halosulfuron-methyl resulted in loss of vigor of tomatoes for 6 weeks but thereafter the vigor was equal to plants in the control. There was no vigor loss of tomatoes from the pre-plant or postemergent halosulfuron-methyl treatments. Snap beans showed no loss of vigor from any halosulfuron-methyl treatment and muskmelon showed only a short-term injury (2 weeks) from a post emergence application but no injury from preemergent applications. Loss of vigor was observed as smaller plants with no yellowing or leaf curling observed on any crop. Yields of all crops were similar regardless of halosulfuron-methyl treatment. Halosulfuron-methyl applied preemergent in all crops and at all rates gave excellent control of velvetleaf, giant ragweed and common lambsquarters for 6 weeks. Postemergent halosulfuron-methyl treatments did not control common lambsquarters as expected but did control giant ragweed and velvetleaf. Compared to the standard post emergence herbicides, halosulfuron-methyl performed equal to or better than metribuzin in tomatoes and fomesafen in snap beans.

FIELD PANSY CONTROL IN NO-TILL FIELDS WITH FALL AND SPRING HERBICIDE APPLICATIONS. Jason N. Miller, David L. Regehr, and Dallas E. Peterson, Graduate Research Assistant and Professors, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Field pansy (*Viola rafinesquii*) is becoming a problematic weed in no-till fields in northeast Kansas. It is a winter annual native to North America, that can germinate both in the fall and spring. This weed grows in thick patches that when left uncontrolled can utilize the stored soil moisture affecting the following crop. Previous work has shown poor or erratic weed control from many spring burndown treatments. Field studies were established in the fall of 2002 in two northeast Kansas no-till fields, to evaluate various herbicide tank-mix combinations at two application timings (fall and spring) on field pansy control. The first field was going to corn where the previous crop had been soybeans, while the second field was going to soybeans that had previously been corn. Ahead of corn, fall-applied treatments ranged from 85% to 100% control. Treatments containing atrazine averaged 98% control vs. 90% without atrazine. Spring-applied treatments provided control similar to the fall applications ranging from 83% to 100%. Ahead of soybeans, most of the fall-applied treatments provided good control ranging from 75% to 100%, with similar results obtained from the burndown-only treatments and residual treatments. In the spring-applied treatments, control ranged from 46% to 90%, and most of the treatments provided far less control than when applied in the fall. One reason less control may have been obtained from the spring-applied treatments ahead of soybeans could be due to the fact that there was more crop residue, and spray coverage could have been affected. Pending further information on how much spring germination does occur and control from spring applied herbicides, it is best to use fall-applied herbicides that provide foliar burndown with adequate residual to control spring germinators.

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 and 2003 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 and May 22, 2003. Herbicide treatments were applied with a CO_2 backpack sprayer to plots arranged in a randomized complete block design with three replications. The plot size was 3 m by 7.5 m in 2002 and 3 m by 9 m in 2003. All applications were made using a carrier volume of 234 L/ha in 2002 and 187 L/ha in 2003. All glyphosate applications included ammonium sulfate at 3% by weight. Visual evaluations of Asiatic dayflower control were made throughout both seasons.

Applications of clomazone and of flumioxazin made 3 to 5 days after planting did not provide acceptable control of Asiatic dayflower in either year. 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 in 2002. Postemergence applications of carfentrazone-ethyl at rates up to 7 g ai/ha to 2- to 15-cm Asiatic dayflower did not provide acceptable control of the weed in 2003. 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 in early July did not provide acceptable control of the weed in either year. However, more timely glyphosate applications did provide better control. Three glyphosate applications of 0.84 kg ae/ha made soon after planting, in mid-June, and in early July to 2- to 20-cm Asiatic dayflower provided greater than 80% control in both years. Glyphosate at 0.84 kg ae/ha applied soon after planting followed by glyphosate at 1.26 kg/ha applied to 2- to 20-cm Asiatic dayflower in mid-June provided greater than 80% control of the weed in 2003, but not in 2002. Cloransulam-methyl at 18 g/ha applied to 2- to 20-cm dayflower provided greater than 80% control in 2002, but not in 2003. The greatest control with soil-applied herbicides occurred with cloransulam-methyl and with sulfentrazone in both years.

A WISCONSIN AGRICULTURAL FOCUS GROUP ADDRESSES GLYPHOSATE RESISTANCE. Chris M. Boerboom and Richard T. Proost, Professor and Regional Agronomist, Department of Agronomy and Nutrient and Pest Management Program, University of Wisconsin, Madison, WI 53706.

The introduction and rapid adoption of glyphosate-resistant crops in Wisconsin has provided many benefits. However, many individuals have expressed concerns about the potential of glyphosate-resistant weeds. Because this issue may affect many sectors of Wisconsin's agriculture, University of Wisconsin Extension decided to host a focus group to determine the level of concern about resistance among these sectors and determine what additional information may be needed by our agricultural industry. This focus group meeting was called the Glyphosate Resistance Roundtable.

Two representatives from each of the following sectors were invited to the Roundtable: dairy producers, corn growers, soybean growers, vegetable growers, independent consultants, pesticide dealers, extension agents, and university weed scientists. Invitations were limited to foster an open discussion. Thirteen individuals attended as Roundtable participants. The single day meeting was facilitated by an experienced community resource extension agent so that university weed scientists could participate and lessen the potential influence on the comments of the participants. A non-participating recorder kept notes. The Roundtable began with an introduction of goals and participants. This was followed by three 20 minute presentations by one out-of state university scientist and two corporate industry experts on resistance. The intent of the presentations were to provide information on the current scope of the glyphosate resistance problem, an understanding of future potential for development, and implications of resistance so that all participants were informed. The next phase assessed the level of concern by having each participant describe and rate their concern on a scale of 1 (none) to 5 (high). Following lunch, the facilitator summarized that nine of out of 13 participants were moderately concerned (rating of 4) and four participants were highly concerned (rating of 5) about glyphosate-resistant weeds. The issues and concerns were grouped into economic, education, biological, environmental, and managerial concerns. In general, participants felt grower acceptance of glyphosate technology was unprecedented and were worried about the loss of the technology due to the development of resistant weeds. The Roundtable was then asked what additional information was needed and steps that should be taken. Numerous ideas were suggested and many related to educational needs directed towards educating growers on the issue, being proactive, and developing a white paper that can be endorsed by Wisconsin's agricultural industry. Following this discussion, the speakers were invited to comment on suggestions for Wisconsin from their national perspectives. They noted numerous complexities with the topic including the rarity of resistance, how to get growers to adopt glyphosate stewardship, and the need for a consistent message. It should be noted that the speakers' participation was intentionally limited in the Roundtable so that the input from the Wisconsin participants was not inhibited. The Roundtable concluded with the participants being asked if anyone objected to exploring the ideas on glyphosate resistance management for Wisconsin. There were no objections and there were suggestions for continued education and publicity.

Roundtable participants were surveyed on their perceptions of the format of this event using a 1 (low) to 5 (high) scale. Participants rated the effectiveness of the presentations at increasing their knowledge about glyphosate resistance as a 3.6, which may indicate they were already familiar with many of the issues. Participants rated effectiveness of the Roundtable's format to allow expression of their views as a 4.2. One person commented that they liked that "industry was involved" and another felt that the presence of industry speakers at the discussion portion may have inhibited comments. Participants rated the Roundtable as a very appropriate way for Wisconsin to address the issue (4.4) and noted the grass roots approach. Participants found the Roundtable to be of value personally (4.1) and for the industry as a whole (4.4) although it was early in the total process. All the participants believed this format should be used to approach other state agricultural issues.

2003 North Central Weed Science Society Proceedings 58:174.

AN INTEGRATED RULE-BASED AND CASE-BASED EXPERT SYSTEM FOR HERBICIDE INJURY DIAGNOSIS. Jingkai Zhou, Janet Davidson-Harrington, and Calvin G. Messersmith, Research Specialist, Research Specialist, and Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Herbicides, when selected and used properly, seldom cause unacceptable crop injury, but injury can occur under some conditions. Unacceptable injury most often results from herbicide carryover, drift, misapplication, or equipment contamination. The environment and crop genetics also can have a large influence on the severity of crop injury. Diagnosis of herbicide injury is often difficult, particularly for a non-expert, because of the large number of factors involved. Computer-based expert systems have great potential for solving this problem.

Expert systems use an artificial intelligent reasoning method to solve complex problems within a specialized domain that ordinarily requires human expertise. Rule-based systems (RBS) and case-based systems (CBS) are probably the best-known and most widely used expert systems. They use different formats representing knowledge and different approaches to search for patterns in the knowledge base. The basic unit and format of knowledge in RBS is the rule and in CBS is the case. A rule is represented by the IF-THEN form, where the IF part is called the condition and the THEN part is called the action. A RBS is built on the idea that if the information supplied by the user satisfies the conditions in a rule, then the actions of the rule are executed. CBS attempt to solve a new problem by making an analogy to an old one and adapting its solution to the current situation. RBS and CBS have their strengths and limitations. The goal of integrating the two systems is to augment the positive aspects of the two approaches and simultaneously minimize their negative aspects.

HIDES (Herbicide Injury Diagnosis Expert System) is a Windows-based integrated rule- and case-based system. The general architecture of HIDES consists of user interfaces, a knowledge base, a rule-based subsystem, and a case-based subsystem. The knowledge base consists of basic information about common herbicides and injury diagnostic knowledge represented via rules or cases. The rule-based subsystem is used to determine the suspect herbicides and possible source of the suspect herbicides. The case-based subsystem is used to determine the reason or cause of injury.

DEVELOPING A FIELD SURVEY FOR THE ESTIMATION OF GLYPHOSATE-RESISTANT HORSEWEED IN INDIANA. Jeff W. Barnes, William G. Johnson, and Kevin D. Gibson, Post-Doctoral Research Associate, Assistant Professor, and Assistant Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Discovery of horseweed in Indiana that is resistant to glyphosate in the fall of 2002 sparked interest from producers, crop advisors, extension personnel and industry representatives. A common theme to questions about the problem centers on the geographic distribution and frequency of glyphosate-resistant horseweed in Indiana. The objective was to develop a field survey system in which both geographic distribution and frequency of occurrence could be determined for horseweed. Counties in Indiana were selected for sampling based upon a point system which facilitated establishing an order for sampling. The point system was designed to place highest priority on counties with confirmed or suspected glyphosate-resistance and counties which had a high percentage of cropland in conservation tillage systems. Information on the acreage of corn and soybean devoted to different tillage systems was provided by the Conservation Tillage Information Center.

Survey sites were randomly pre-selected using maps developed from digital aerial raster imagery (orthophotos) originally developed by the United States Geological Service and Natural Resources Conservation Service and the 2000 Cropland Data Layer program conducted by the National Agricultural Statistical Service. Orthophotos and Cropland Data Layers for Indiana counties were compiled by the Purdue Center for Advanced Application in Geographic Information Systems. Maps were developed in the ArcView GIS 3.2 software program. Survey sites were selected in areas where land use was primarily devoted to soybean and corn production. The coordinates for the randomly selected fields were downloaded to a GPS unit and a route was developed to facilitate efficient travel time between survey sites. Information gathered at the survey site included presence of horseweed at the site, current crop, field tillage system, and presence of other weed species. If horseweed was present at the survey site seed from forty plants was a sampled and subjected to screening in the greenhouse to determine if the horseweed was resistant to glyphosate. Since soybean was our primary crop of concern, if a pre-selected point was a planted to corn the point was moved to a soybean field within 1-km of the pre-selected site. If a survey site was not a soybean or corn field the survey site was moved to the closest soybean field. The random survey system was supplemented by taking additional samples from cropland in which horseweed were clearly visible from the road. The supplemental sample points were included as a means of identifying potential problem fields within a geographic range in which horseweed was not readily observed and pre-selected survey sites. Supplemental survey sites were not included in data analysis designed to answer the question of frequency of glyphosate-resistant horseweed in Indiana fields as this would have biased the answer.

In the fall of 2003, 792 sites were surveyed for the presence of horseweed in Indiana. Most of the points were in southeast Indiana where the first populations of glyphosate-resistant horseweed were discovered. Of the sites surveyed, 80% were from the randomly pre-selected sites and the remainders were a combination of sites from non-cropped areas, supplemental sites, and fields brought to our attention by producers or crop advisors. The random selection of survey sites from the orthophotos and Cropland Data Layer successfully identified a soybean or corn field with 85% accuracy. Approximately 40% of the sites identified corn fields and most of those sites were moved to a soybean field in close proximity. The combination of the pre-selected sites and supplemental sites have developed good county level maps depicting the geographic distribution and frequency of horseweed prior to crop harvest in Indiana. The data from resistance screening data, tillage system information from the Conservation Tillage Information Center, and data from a producer survey conducted in cooperation with the Indiana Agricultural Statistical Service will be combined to develop risk zone maps fully describing areas in Indiana at different risk levels of having glyphosate-resistant horseweed populations develop.

COMMON DANDELION CONTROL WITH POSTEMERGENCE CORN HERBICIDES: A TWO-YEAR SUMMARY. Aaron S. Franssen* and James J. Kells. Michigan State University, East Lansing, MI 48824.

Common dandelion has become an established perennial weed in Michigan no-tillage crop production. It is likely that as the adoption of no-tillage increases, the occurrence of common dandelion will also increase. To address this issue, several postemergence corn herbicides were evaluated for control of established common dandelion. Field trials were conducted in 2002 and 2003 near Clarksville and Ovid, respectively, in south central Michigan. Glufosinate-resistant corn was planted in 76-cm row spacing. Herbicide treatments were applied when corn reached the V5-V6 growth stage. Common dandelion control was evaluated visually at 3 and 8 weeks after treatment (WAT).

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

Similar results were observed in 2002 and 2003. Treatments that consistently provided control of common dandelion over 80 percent 3 WAT included; mesotrione, mesotrione + atrazine, and glufosinate + atrazine. By 8 WAT, control ratings were reduced due too regrowth of common dandelion. The most effective treatment at 8 WAT was diflufenzopyr + dicamba with 77 and 90 percent control in 2002 and 2003, respectively.

IMPACT ON WEED PRESSURE BY EXPANDING THE CORN-SOYBEAN ROTATION TO INCLUDE WINTER WHEAT. Kevin B. Shelley and Jerry D. Doll, Outreach Educator, Nutrient and Pest Management Program and Extension Weed Scientist, Department of Agronomy, University of Wisconsin-Madison, Madison, WI 53706.

Crop rotation is often mentioned by researchers and educators as a component in an integrated approach to managing pests. Measuring or demonstrating its efficacy is less common, particularly in actual production situations. The objective of this six-year on-farm research and demonstration project is to help corn and soybean farmers in southern Wisconsin recognize potential agronomic, economic and pest management benefits associated with more diverse crop ecology. It compared a soybean-corn rotation with an expanded rotation of soybean-winter wheat-corn in which medium red clover is frost-seeded into the wheat in early spring to provide a post-harvest cover crop. Rotations have been compared on three cooperating farms in south-central Wisconsin in field-length, side-by-side, strips with two or three replications of each rotation. The comparisons were run on farms in Dane and Columbia Counties from 1998 to 2002 and on a farm in Iowa County from 1999 to 2003.

Observing weed pressure in each rotation has been the primary pest management focus. It was expected that adding a winter annual crop and legume forage cover crop to an otherwise continuous annual crop rotation would break the cycle of annual weeds, thus reducing their pressure in the year that corn follows wheat. This would be similar to the commonly observed effect of alfalfa on annual weed pressure when rotated back to corn. This would provide an additional cultural component to weed control in what is mostly a chemically based control program.

Weed pressure in each rotation was evaluated by two methods. The first involved weed seedbank sampling in which weed seeds were germinated in greenhouse flats from intensively collected soil samples in each of the field-length strips in each of years two through six of the project. The second approach made in-field weed counts in early June of the final year before any herbicides (other than preplant Glyphosate burndown) were applied. In the final year, the soybean-wheat/red clover-corn rotation had been through two complete cycles.

Contrary to our expectation, weed pressure did not appear reduced in the rotation including winter wheat/red clover. From the seedbank sampling, weed seedlings per-square-foot were higher in soil sampled from the wheat/red clover rotation for 13 of the 15 site-years sampled, though many of the differences are likely not statistically significant. Final-year weed seedlings per-square-foot were higher in the wheat/red clover rotation for two of the three cooperating farms. It is not known why, but weed pressure as measured by the seed-bank method declined in both rotations on all three farms during the 6-year period. Weeds observed in the field in the project's final year were significantly higher in the wheat/red clover rotation on two of the three farms.

On the surface, these findings would argue against the efficacy of the more diverse rotation as part of an integrated approach to weed management. However, possible competition advantages afforded crops grown in the more diverse rotation must also be considered. Economic results favored the three-crop rotation on two of the three farms in the comparison. This was due to: (1) slightly higher corn and soybean yields in that rotation, and (2) relatively high wheat yields. Teaching the agronomics for high-yield wheat was another component of the project.

ITALIAN RYEGRASS CONTROL PRIOR TO NO-TILL. 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 the year following the cover crop if seed development is not prevented. One such cover crop is Italian ryegrass. Volunteer plant development from the seed produced by escape plants can occur the following fall or early spring. Control of these plants in the spring prior to no-till crop production is just as important for the elimination of future weed pressure.

The objective of this study was to evaluate spring herbicide applications for control of volunteer Italian ryegrass prior to no-till crop production. The herbicide treatments included single and combination treatments of glyphosate, AMS, paraquat, atrazine and metolachlor.

Italian ryegrass seed was broadcast over the entire trial area at 66 kg/ha on October 23, 2001. The trial area was chopped for forage on May 28, 2002. After allowing regrowth the entire trial area was sprayed with 1.68 kg ae/ha on June 19, 2002. Any surviving plants were allowed to mature and produce seed. Emerging plants from those that produced seed were treated with various herbicide treatments on March 25, 2003. The Italian ryegrass plants were 10 to 25 cm in height and in the late tillering stage of growth.

Control results 14 days after application indicated that control continued to significantly increase as the glyphosate rate increased to the high use rate of 3.37 kg ae/ha. At that rate control was 80%. The addition of 1% AMS significantly increased control to 89%. The use of paraquate+atrazine provided 76% control. The combination of paraquate+atrazine+metolachlor provided 83% control. The combination of glyphosate+atrazine+metolachlor provided only 45% control.

Control results 28 days after application significantly increased for the treatments containing combinations with atrazine, while the glyphosate treatments remained constant or declined. The treatments of paraquate+atrazine and paraquate+atrazine+metolachlor increased to 90% control. This was significantly better control than the high rate of glyphosate+AMS at 83%, and the combination of glyphosate+atrazine+metolachlor at 73%. The glyphosate rate of 0.84 kg ae/ha produced less than 50% control.

These control results with these herbicide treatments indicate that significant seed production from surviving plants could produce continued volunteer weed pressure at least two years after the establishment of the Italian ryegrass cover crop.

CURRENT STATUS OF HERBICIDE RESISTANT WEEDS IN OHIO. Jeff M. Stachler and Mark M. Loux, Weed Science Extension Program Specialist, Associate Professor, Ohio State University, Columbus, OH 43210.

Greenhouse research conducted in Ohio prior to 2002 confirmed the presence of ALS-resistant Powell amaranth in Hancock County, common cocklebur in Miami County, horseweed in seven counties, common ragweed in 20 counties, giant ragweed in 11 counties, shattercane in Fairfield County, and waterhemp in nine counties, atrazine-resistant common lambsquarters in Fairfield County, and 2,4-D resistant wild carrot in Williams County. Further greenhouse research has been conducted to confirm herbicide resistance in other species.

In 2001, smooth pigweed seed was collected from one field in Madison County, Ohio. Greenhouse studies conducted in late 2001 and early 2002 using thifensulfuron, flumetsulam, and imazamox POST at 2X rates (0.125 oz ai/A, 1.6 oz ai/A, and 0.625 lb ai/A, respectively) showed 20, 4, and 98% control of smooth pigweed, respectively.

In 2001, approximately 48 new Ohio horseweed populations were collected. Each population was screened with cloransulam at 1 (0.25 oz ai/A) and 4X rates and glyphosate (Roundup UltraMax) at 1 (0.75 lb ae/A) and 4X rates. The results of this study showed that ALS-resistant horseweed was in eight additional Ohio counties and there was no glyphosate-resistant horseweed, although there were a few populations that showed statistically lower control compared to the sensitive check, indicating increased tolerance to glyphosate.

Common lambsquarters seed was collected in 2001 from Putnam County, but greenhouse research was not conducted until 2003. Thifensulfuron and imazamox was applied at 2X rates (0.125 oz ai/A and 0.625 lb ai/A, respectively). Thifensulfuron and imazamox controlled this population at 34 and 90 %, indicating the presence of ALS-resistant common lambsquarters in Ohio.

Twelve horseweed samples were collected from six Ohio counties in 2002. These populations were screened with cloransulam at 1 (0.25 oz ai/A) and 4X rates and glyphosate (Roundup UltraMax) at 1 (0.75 lb ae/A) and 4X rates. Results indicated presence of 10 glyphosate-resistant horseweed populations from Brown, Clermont, Clinton, and Highland Counties (southwest Ohio) and two new ALS-resistant populations from two new counties.

The results from a demonstration study conducted early this fall confirmed the presence of atrazine-resistant common lambsquarters in Darke County.

During September and October 2003, approximately 90 new horseweed populations were collected from 23 Ohio counties. Based upon one preliminary study, glyphosate-resistant horseweed is present in Montgomery County, Ohio. Thirty-four of the 90 populations are currently being screened in the greenhouse with cloransulam at a 4X rate and glyphosate (Roundup UltraMax) at 1 and 4X rates.

In summary, Ohio has confirmed nine ALS-resistant biotypes and one glyphosate-, atrazine-, and 2,4-D-resistant biotype. To date glyphosate-resistant horseweed has been confirmed in a total of five Ohio counties and highly suspect that it is in several other counties.

INVASIVES DRAW CROWDS IN WISCONSIN - HOW DO WE CAPITALIZE ON THE MOMENT?

Jerry D. Doll. Extension Weed Scientist, University of Wisconsin, Madison, WI 53706.

The term "invasive plants" is more than a buzz word and activities built around this topic usually draw crowds. In Wisconsin, for example, conferences on invasives in 2001 and 2003 drew over 600 participants: more than we often have at NCWSS annual conferences. Why are invasives drawing so much attention? The reasons are numerous and vary from state to state but clearly undesirable plants are invading new areas and people see and react to this phenomenon.

For the most part, those of us at Midwestern Land Grant Universities are not key players in this arena. We often see Depts. of Natural Resource and perhaps Agriculture personnel leading noxious weed efforts. This is fine but these agencies are not primarily research and outreach institutions, and at a minimum we must be sure we are part of the team that develops and leads noxious weed efforts. Many of our colleges of agriculture now clearly include natural resources within their mandate and as such are well positioned to be leaders in the research, outreach and teaching efforts that will be keys to successful invasive plant programs.

Here are ten ways to help us capitalize on the popularity of invasives at the moment and help ensure that efforts continue if and when the enthusiasm dwindles. By starting now, weed scientists can contribute the skills, knowledge and leadership that will help this worthwhile cause.

1. Become part of efforts to create or revise noxious weed laws. Most noxious weed laws were just that: laws. The goal should be to create invasive plant programs. Weed scientists can provide a solid framework of how to design effective research and outreach components of invasive plant programs.

2. Previous noxious weed laws were developed from an agricultural perspective. Today's concerns with invavises are much broader and include natural and aquatic areas, roadsides, forests and woodlands, prairies and green areas such as lawns, parks, trails and more. Some agricultural plants are invasive in noncrop areas. It is not unusual to see turf species (Kentucky bluegrass) and forage grasses (reed canarygrass) and legumes (birdsfoot trefoil) as potential noxious weeds. We must ensure that agriculture is represented when species are added or removed from noxious weed lists.

3. Bring the invasive plant issues into our weed science courses and training programs on campus. This is needed in our identification, management and weed ecology and biology courses. We could have graduate students and interns with invasive plant projects.

4. Add invasive plant research and outreach activities to weed science faculty position descriptions. This could be a logical component of weed ecology and biology research and teaching positions as well as those of campus and regional extension weed scientists.

5. Explore ways to interact with botanists, horticulturalists, economists, wildlife biologists, foresters and others on campus to develop and coordinate activities on invasive plants. Perhaps it would be better to do this on invasive species at the campus level with subgroups that deal with plants, insects, etc.

6. Know the organizations involved with invasive plants in your state. In Wisconsin, this means The Nature Conservancy, Dept. of Natural Resources, Prairie Enthusiasts, the Invasive Plants Association of Wisconsin(IPAW), the NRCS, the Department of Defense (the biologist at Ft. McCoy has a team of people involved with invasive on the military land).

7. Be available to work with local citizen groups that focus on invasive plants. More township, city and county level groups are appearing in Wisconsin and they are eager for information and training and are more than willing to take action once an appropriate action plan is developed.

8. Create educational materials that focus on invasive plants and place these on the internet. The "Agronomy Advice" items I prepared on Japanese knotweed and garlic mustard are on the UW Weed Science web site have been used often by new audiences well beyond Wisconsin.

9. Establish pilot projects that demonstrate how to implement an invasive weed management program. We need local examples of successful efforts to train, educate and motivate others in the battle with invasive plants.

10. Keep your eyes open for new initiatives. In Wisconsin, several counties are using NRCS Environmental Quality Incentives Program (EQIP) monies to control multiflora rose. Land owners must prepare a three-year action plan to receive partial financial support to implement the plan. We can be a valuable resourse in developing plans and assessing the results.

CHRISTMAS TREE AND WEED RESPONSE TO FLUMIOXAZIN. Robert J. Richardson*, Bernard H. Zandstra, and Jill O'Donnell, Michigan State Univ., East Lansing, MI 48824.

Flumioxazin is currently under development for use in Christmas tree plantations. Research studies were conducted in 2002 and 2003 to evaluate response of blue spruce and selected weeds to flumioxazin and herbicide mixtures with flumioxazin. In a program comparison study, flumioxazin (0.4 kg ai/ha) was applied alone and in mixture with pendimethalin (3.4 kg ai/ha) on November 12, 2002. Comparison treatments included simazine (2.2 kg ai/ha), isoxaben (1.2 kg ai/ha), oxyfluorfen (1.2 kg ai/ha), and sulfentrazone (0.6 kg ai/ha), each in mixture with 3.4 kg/ha pendimethalin, and a non-treated control. Blue spruce visible injury on June 11, 2003 was 5% with flumioxazin plus pendimethalin and 9% with sulfentrazone plus pendimethalin. Visible injury on August 28, 2003 was 6% with sulfentrazone plus pendimethalin, but injury was not present with other treatments. The predominant injury symptom was needle necrosis and new growth was not affected. Horseweed (*Conyza canadensis*) and dandelion (*Taraxacum officinale*) control on July 16, 2003 did not differ by treatment and averaged 87% and 72%, respectively. Virginia pepperweed (*Lepidium virginicum*) control was at least 80% with all treatments, except oxyfluorfen plus pendimethalin at 47%. Common catsear (*Hypochoeris radicata*) control was 73% with flumioxazin plus pendimethalin and 87% with simazine plus pendimethalin, but did not exceed 67% with other treatments. On August 28, 2003, horseweed control exceeding 78% with only flumioxazin, flumioxazin plus pendimethalin, and sulfentrazone plus pendimethalin. Annual grass control was greater than 80% with all treatments containing pendimethalin, but was 67% with flumioxazin alone. In a flumioxazin program study, flumioxazin was applied alone at 0.14, 0.28, and 0.4 kg/ha on May 6, 2003. Other treatments included flumioxazin at 0.28 kg/ha in mixtures with pendimethalin (3.4 kg/ha), s-metolachlor (1.3 kg ai/ha), simazine (1.68 kg/ha), and simazine plus pendimethalin, a comparison treatment of simazine plus oxyfluorfen (0.56 kg/ha) plus pendimethalin, and a non-treated control. Visible injury on June 11, 2003 was 12% with treatments containing flumioxazin plus pendimethalin. Injury was not observed with other treatments and visible injury was not present on August 28, 2003. Horseweed and dandelion control exceed 80% with all treatments on July 16, 2003. Control of false dandelion was greater than 70% with treatments containing flumioxazin plus simazine and with flumioxazin plus pendimethalin. Annual grass control on August 28, 2003 was at least 86% with treatments containing pendimethalin or s-metholachlor, but was 70% with 0.14 kg/ha flumioxazin and flumioxazin plus simazine.

IMPACT OF AG INDUSTRY DOWNSIZINGS AND MERGERS ON THE WEED SCIENCE PROFESSION, INDUSTRY-UNIVERSITY RELATIONSHIPS, AND OUR OWN CAREERS.

David H. Johnson, Senior Research Associate and Associate Professor, Penn State University, Manheim, PA 17545.

There have been dramatic changes in the crop protection industry in the past decade or so. There were at least 24 companies actively engaged in new herbicide research and development when I started graduate school in 1985. When I finished my Ph.D. in weed science in 1992 there were about 15. Now there are about 8, and most of these have scaled back new herbicide discovery efforts in favor of crop trait development or discovery efforts in pathology and entomology. On the other hand, there are 91 manufacturers listed on cdms.net under ag/crop and 81 listed under T and O/non-crop. This indicates that there are a lot of companies selling crop protection products in several markets. Many of these companies sell generic pesticides (glyphosate, atrazine, trifluralin, phenoxys, etc.), adjuvants, nutrients, and biocontrol agents. A few have fairly large research and service operations.

Company mergers and downsizings, combined with less hiring in the public sector, have resulted in fewer job opportunities for new graduates and for those forced to look for new work due to job loss. There is much more competition for those few jobs that are available. Field rep territories have been enlarged, job functions combined (sales, service, and R and D), and there is less service at the grower level. Job security has certainly decreased.

In universities, budget cuts have also forced downsizings, both in faculty and staff positions, and decisions not to replace retired faculty are common. Decreased support from industry in areas such as product testing has also reduced resources. Many universities are not replacing retired crop breeders, and those that are left often have very limited access to new crop traits. I believe that this will lead to fewer qualified graduates with expertise in classical breeding and genetics, an area in which many companies are expanding their efforts.

In industry-university relationships, there is now less face-to-face time between industry reps and university weed scientists. This and higher turnover among reps makes it more difficult to develop working relations. There is also much less interaction and networking with graduate students compared to 10 to 15 years ago. Attendance at weed science field days has declined dramatically, and many universities have discontinued them or made them part of experiment station field days. Other issues include shorter times to market launch, which means extension faculty have less time to evaluate new products, cost recovery at universities (facilities and administration charges, experiment station land charges), and limited access to new technologies. These and other issues may further decrease the amount of interaction that occurs.

Weed scientists of the future must not be purely herbicide technologists, but must have a broader base of knowledge of cropping systems management, including weed biology, soil and environmental chemistry, genetics, biotechnology, agronomy, crop protection, invasives, non-crop, T and O, social and business issues, and yes, herbicides. I believe that we must become more generalists rather than specialists to survive in this field for our careers, and we should be training our students in this way.

I believe that the future of weed science is secure because weed scientists address issues of importance to society, such as food production and safety, environmental quality, bioterrorism, etc.). However, we must be willing to join forces with other disciplines to address global issues on the <u>cropping system</u> and <u>landscape</u> levels, not just at the weed control level. Private industry and the public sector must work together to ensure this future, and continue to attract bright students to pursue this career path.

EFFECT OF DELAYED GLYPHOSATE APPLICATIONS ON WEED CONTROL AND SOYBEAN YIELD IN LATE-PLANTED SOYBEAN. Ronald F. Krausz and Bryan G. Young, Researcher and Associate Professor, Department of Plant, Soil and General Agriculture, Southern Illinois University, Carbondale, IL 62901.

Soybean producers routinely delay postemergence herbicide applications in glyphosate-resistant soybean to reduce glyphosate applications. Therefore, the objective of this research was to evaluate the effect of delayed glyphosate applications on weed control and soybean grain yield in late-planted soybean. Sulfentrazone plus cloransulam applied preemergence followed by glyphosate postemergence controlled 98 to 100% of velvetleaf, common waterhemp, ivyleaf morningglory, yellow nutsedge, Palmer amaranth, giant foxtail, and common cocklebur. Glyphosate alone controlled 2- to 8- inch velvetleaf, 72 to 77%. Therefore, a sequential application of glyphosate was required to achieve 90% or greater velvetleaf control. A single glyphosate application provided 90 to 100% control of 8- to 36-inch velvetleaf, common waterhemp, ivyleaf morningglory, yellow nutsedge, Palmer amaranth, giant foxtail, and common cocklebur. Glyphosate controlled Palmer amaranth, giant foxtail, and common cocklebur, 100%, regardless of weed height. Weed competition did not reduce soybean height. Soybean maturity was delayed by seven days in the nontreated. Soybean grain yield ranged from 16 to 47 bu/A. The greatest yield was obtained where sulfentrazone plus cloransulam was applied preemergence followed by glyphosate postemergence. Yields were significantly reduced as the glyphosate application was delayed beyond the 8-inch weed height. Despite 90% or greater weed control with a single glyphosate application, yield reductions ranged from 8 to 26 bu/A.

TECHNICAL EVALUATION OF A NEW POTASSIUM SALT OF GLYPHOSATE FORMULATION. Erika J. Ehler, Jeffrey A. Koscelny, David C. Heering, Dawn Wyse-Pester and Paul G. Ratliff, Technology Development Representative and Technology Development Managers, Monsanto Co., St. Louis, MO 63167.

Field and laboratory research trials were conducted during 2002 and 2003 to determine the physical characteristics and the efficacy profile of a new potassium salt of glyphosate (Roundup Original MAX) formulation. Roundup Original MAX contains 4.5 lbs glyphosate acid equivalent per gallon and is formulated using the potassium counter ion. Roundup Original MAX is a complete formulation containing a unique delivery system. The specific gravity of the formulation is 1.3565 with a gallon of formulated product weighing 11.297 pounds. Eighty-seven small-plot field efficacy trials were conducted throughout the U.S. to evaluate performance. At labeled rates, Roundup Original MAX provided reliable control of annual and perennial weeds. In 728 side-by-side observations with competitive formulations, Roundup Original MAX provided statistically equivalent weed control versus Glyphomax Plus and Touchdown IQ and statistically better weed control versus Glystar Plus (P=0.05). Glyphosate tolerant (Roundup Ready) crop response to applications of Roundup Original MAX when no additional nonionic surfactant was added ranged from minimal to no affect with no impact on yield. Roundup Original MAX is currently being commercialized throughout most of the United States.

New Touchdown® Formulations from Syngenta Crop Protection. Venance H. Lengkeek and Charles L. Foresman. Syngenta Crop Protection, Greensboro, NC 27419

Syngenta Crop Protection has been developing and marketing Glyphosate products since the introduction of Touchdown 5® in 1996. This product, which was formulated as a 3.45 AE/Gal trimethyl sulfonium salt of Glyphosate, was soon replaced in the market with a new and improved 3.0 AE/Gal, Diammonium salt of Glyphosate, with the trade name of Touchdown IQ®. Touchdown IQ® is currently registered in over 230 crops including Glyphosate corn, soybeans, and cotton.

In 2003, Syngenta Crop Protection, introduced several new Glyphosate products for testing. A13013M is a 4.17 AE/Gal product formulated as the Potassium salt of Glyphosate with a uniquely built-in, balanced adjuvant system. A13998A is a 5.0 AE/Gal product formulated as the Potassium salt of Glyphosate. This product has no built-in adjuvant system. A13886A is a product containing the Potassium salt of Glyphosate at 2.25 AE/Gal plus s-metolachlor at 3.0 AI/Gal.

Control of Giant foxtail, Common lambsquarters and Velvetleaf with A1303M is equal to that of Roundup WeatherMax™ at acid equivalent rates, while control of these same weeds with A13998A is equivalent to that of Roundup Original™ at acid equivalent rates. Control of Giant foxtail and to some degree Common lambsquarters with A13886A is increased over that Glyphosate alone due to the addition of s-metolachlor.

GLYPHOSATE EFFICACY WHEN TANK MIXED WITH FOLIAR APPLIED MN FERTILIZERS IN GLYPHOSATE TOLERANT SOYBEAN. Terry W. Semmel, Jeff Hinen, Greg Elmore, Phil Boeve, Jeff Taylor, Erika Ehler, Brad Miller. Technology Development Managers, Monsanto Company, St. Louis, MO 63167.

Manganese nutrient deficiencies in soybean (Glycine Max) occur in many Midwestern states. In Indiana, Mn deficiencies are frequently observed in well-drained (sands) alkaline (high pH) soils high in soil organic matter. Multiple applications of foliar applied Mn may be needed when deficiencies are severe. Combining Mn fertilizers with glyphosate applications in Roundup Ready soybean could decrease application costs. Experiments were conducted to determine tank compatability, efficacy of weed control, and crop safety of common Mn fertilizers. Treatments of these in-field experiments included inorganic, organic, and chelated classes of Mn.

Field research was conducted at West Lafayette IN, Perry MI, Ashville, OH, Findlay, OH, Arcanum, OH in 2003 using an randomized complete block design. Herbicide treatments were applied after annual broadleaf and grass weeds reached the 4-8 inch height. In order to separate treatments, glyphosate rates were designed to be slightly below the dose necessary for 100% control.

All Mn fertilizers used in this study were used at manufactures' recommended rates. The organic Mn source was formulated with citric acid, the inorganic source as Mn sulfate, the remaining treatments were synthetic chelated formulations.

Results showed significant decreased weed control with the addition all Mn fertilizers. While overall weed control of all fertilizer treatments was less than the glyphosate standard, significant differenced did exist between weed species as well.

CONTROL OF GLYPHOSATE RESISTANT VOLUNTEER CORN IN GLYPHOSATE RESISTANT SOYBEAN WITH EXPERIMENTAL CLETHODIM FORMULATIONS. Jeffrey D. Smith, Kevin M. Perry, John A. Pawlak and Mark J. Kitt, Field Market Development Specialist, Product Life Science Manager, Product Development Specialist and Field Market Development Specialist, Valent U.S.A. Corporation, Walnut Creek, CA 94596.

The vast majority of soybeans produced in the United States are glyphosate resistant. As glyphosate resistant corn acres increase, volunteer glyphosate resistant corn can be troublesome in rotations with glyphosate resistant soybeans. As a result, the use of conventional herbicides such as clethodim, in tank-mixes with glyphosate is becoming increasingly important.

Clethodim is widely used in soybeans for control of annual and perennial grasses as well as volunteer corn and cereals. However, clethodim performance is dependent on the addition of crop oil concentrate (COC) or methylated seed oil (MSO) for optimal uptake and translocation within susceptible grass species. The use of COC or MSO is not recommended with most glyphosate applications due to antagonism concerns. Therefore, as a continuation of the clethodim isomer project, Valent U.S.A. Corporation initiated a research program to develop a clethodim formulation to meet the uniqueness of this use pattern. The objective of this research was to: 1) eliminate dependence on COC or MSO, 2) be flexible in tank-mixes with various glyphosate formulations (with and without built-in adjuvant systems), and 3) provide control equal to or superior to the commercial standard of clethodim (Select 2 EC) plus COC or MSO. Valent U.S.A. Corporation has developed V-10137; an enhanced clethodim formulation that meets those criteria.

Internal and external data indicates that only the adjuvant required by the glyphosate formulation is needed to achieve excellent control of volunteer glyphosate resistant corn when tank mixed with V-10137. Data also indicates that V-10137 does not antagonize glyphosate performance. V-10137 will be formulated as an emulsified concentrate (EC) containing 1.0 pound of clethodim per gallon. A limited launch of V-10137 will be initiated in 2004 within certain geographies.

EFFECT OF TILLAGE REGIME AND TIMING OF GLYPHOSATE APPLICATIONS ON TRUMPETCREEPER (*CAMPSIS RADICANS*) IN GLYPHOSATE-RESISTANT SOYBEAN.

Michael W. Marshall and J.D. Green, Research Specialist and Extension Specialist, University of Kentucky, KY 40546.

The adoption of conservation or no-tillage production has resulted in dramatic and beneficial changes in soil physical properties. In Kentucky, the soils and topography are well suited to these limited tillage production systems because they allow an effective means to reducing soil erosion and plant nutrient losses by water while growing a crop on sloping land. However, one the major drawbacks to no-tillage production is the increase of populations of difficult to control perennial dicots, such as trumpetcreeper. This species remains difficult to manage with normal in-season use rates of glyphosate. Delaying herbicide treatment of trumpetcreeper to the late-season/fall period (either preharvest or after crop removal) would potentially result in more herbicide translocated into the underground root tissue. The objectives of this study were to establish a uniform population of trumpetcreeper, to evaluate the following season after transplanting the impact of tillage regime on established trumpetcreeper population, and to evaluate control and population changes on established trumpetcreeper the following season after various rates and timings of glyphosate treatments. Field experiments were conducted in Central Kentucky at Lexington and in Western Kentucky near Princeton. Experimental design was a split-plot with the main plot being tillage regime and the subplot herbicide treatment. Tillage regime was replicated three times at each location. In the establishment year (2001), trumpetcreeper seeds were collected from fencerows adjacent to roadsides in Nelson County in Central Kentucky. Starting in March 2001, and every year afterward, tillage blocks were tilled using a tandem disk set to a depth of 7.6 cm. No-tillage blocks were undisturbed. To initiate growth and derive a uniform population, seeds were planted in peat tablets in the greenhouse six weeks before transplanting to the field. Seedling trumpetcreeper, at the 2- to3-leaf stage, were transplanted to the field locations (late May to early June). The planting arrangement consisted of 6 plants spaced equidistantly along the center of 3 by 12 m subplot in Lexington and 3 by 10 m subplot in Princeton. One year after transplanting (2002), glyphosate-resistant Asgrow AG4403 soybean (*Glycine max*) was planted on May 28, 2002 in Lexington and May 19, 2002 in Princeton. Trumpetcreeper populations were measured before applying herbicide treatments. In-season herbicide treatments consisted of glyphosate early post (EP) at 0.84 kg ha^{-1}, glyphosate late post (LP) at 0.84 kg ha^{-1}, glyphosate EP at1.68 kg ha^{-1}, glyphosate LP at 1.68 kg ha^{-1} and a preharvest treatment of glyphosate at 1.68 kg ha^{-1}. In-season and preharvest treatments were applied with CO_2 backpack sprayer at carrier volume of 13 L ha^{-1} and a pressure of 138 KPa. Visual control ratings and plant heights were recorded on in-season treatments at 3, 6, and 9 weeks after treatment. Plots were harvested for yield 14 days after the preharvest treatment. All plots were evaluated the following season (2003) for long-term effect on trumpetcreeper populations and control. Data were subjected to ANOVA and means separated at the P = 0.05 level. At both Lexington and Princeton, spring tillage had a significant effect on trumpetcreeper population the season following establishment. In addition, in-season trumpetcreeper control was better with the higher rate of glyphosate. More importantly, trumpetcreeper control was better the season following herbicide treatment with the late season (preharvest) versus in-season treatments. No differences were observed in trumpetcreeper control and plant height between the two in-season glyphosate timings. In Princeton, soybean yield were similar across all in-season treatments, but EP did yield higher than LP treatments. In conclusion, spring tillage provided an excellent tool in the management of trumpetcreeper. In-season trumpetcreeper control was better with the highest rate of glyphosate at both locations. The preharvest treatment provides the best trumpetcreeper control the following season (12 months after treatment). Therefore, a long-term strategy for reducing trumpetcreeper infestation may include the use of late-season/fall herbicides and/or conservation tillage.

2003 North Central Weed Science Proceedings 58:189.

PROTOX-INHIBITING HERBICIDE PERSISTENCE AND PLACEMENT AFFECTS CONTROL OF COMMON WATERHEMP. Dana B. Harder, Kelly A. Nelson, and Reid J. Smeda, Undergraduate Assistant, Assistant Professor, and Associate Professor, Department of Agronomy, University of Missouri, Novelty, MO 63460.

A field in northeast Missouri had a population of common waterhemp (*Amaranthus rudis* Sauer.) with confirmed resistance to protox-inhibiting herbicides in 2002. Preemergence protox-inhibiting herbicide treatments controlled common waterhemp up to four weeks after treatment. Greenhouse research was initiated to evaluate herbicide persistence and placement on the control of protox-inhibiting herbicide resistant common waterhemp.

Protox-resistant common waterhemp seed was collected and planted into containers with herbicide treated soil at two week intervals and rated four weeks after each planting date. A preemergence application of isoxaflutole 70 g ai ha^{-1}, sulfentrazone at 240 g ai ha^{-1}, atrazine at 1680 g ai ha^{-1}, fomesafen at 330 g ai ha^{-1}, and flumioxazin 72 g ai ha^{-1} visibly controlled common waterhemp greater than 85%. In addition, control of common waterhemp was greater than 80% for waterhemp sown two weeks after herbicide application for all treatments except flumioxazin. Isoxaflutole, sulfentrazone, fomesafen, flumioxazin, lactofen at 220 g ai ha^{-1}, acifluorfen at 420 g ai ha^{-1}, and imazethapyr at 70 g ai ha^{-1} controlled common waterhemp 64, 44, 40, 33, 19, 15, and 0%, respectively, at the six week after application planting date.

Soil only, foliar only, and soil plus foliar applications were evaluated to determine the impact of herbicide placement on resistant common waterhemp control. The soil plus foliar placement of flumioxazin at 72 g ha^{-1}, fomesafen at 330 g ha^{-1}, acifluorfen at 420 g ha^{-1}, and lactofen at 220 g ha^{-1} controlled common waterhemp 32, 24, 17, and 8%, respectively, 21 days after treatment (DAT). The foliar only placement of flumioxazin, fomesafen, acifluorfen, and lactofen controlled common waterhemp 15, 13, 13, and 13%, respectively, 21 DAT. The soil only placement did not control common waterhemp. Common waterhemp control was affected by herbicide placement and was ranked: soil plus foliar > foliar > soil.

WINTER ANNUAL WEED MANAGEMENT AND THE IMPACT ON SOYBEAN CYST NEMATODE. Kelly A. Nelson, William G. Johnson, and Jim Wait, Assistant Professor, Department of Agronomy, University of Missouri, Novelty, MO 63460; Assistant Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907; and Research Specialist, Department of Agronomy, University of Missouri., Columbia, MO 65211.

Winter annual weeds may serve as alternative hosts of soybean cyst nematode (SCN) while an increase in winter annual weeds in no-till production has been related to a reduction in residual weed management systems. Research evaluated the impact of winter annual weed management and residual weed management in corn and soybean on winter annual weed control and the impact on soybean cyst nematode egg populations from fall, 2001 to spring, 2003 at Columbia and Novelty. The primary winter annuals at Columbia were henbit and common chickweed while the predominant winter annual at Novelty was henbit. Control of winter annual weeds with preemergence herbicides applied in the spring 2001 and 2002 were compared to a fall 2001 and fall 2002 application timing, respectively. Treatments were maintained on the same plots during the 2001 and 2002 cropping seasons.

In soybean, spring 2002 applied chlorimuron at 0.04 kg ai/ha plus sulfentrazone at 0.22 kg ai/ha, fall 2002 applied chlorimuron at 0.04 kg/ha plus suflentrazone at 0.22 kg/ha, fall 2002 overseeded ryegrass at 28 kg/ha, and fall 2002 overseeded winter rye at 112 kg/ha reduced winter annual total dry weights 46, 100, 65, and 25%, respectively, in the spring 2003. All treatments reduced SCN eggs/200 cm^3 similar to the untreated control except winter rye. Overseeded winter rye increased SCN population 65% when compared to the untreated control in soybean. In corn, spring 2002 applied atrazine at 2.2 kg ai/ha, fall applied simazine at 1.1 kg ai/ha plus tribenuron at 0.018 kg ai/ha, fall 2002 overseeded ryegrass at 28 kg/ha, and fall overseeded winter rye at 112 kg/ha reduced winter annual total dry weights 41, 99, 88, and 84%, respectively, in the spring 2003. None of the treatments reduced SCN egg/200 cm^3 populations when compared to the untreated control.

Residual herbicides applied in the spring reduced total winter annual dry weights the following spring. The change in SCN populations for spring or fall applied weed management systems was similar to the untreated control.

EVALUATION OF PLANTING DATE AND SOIL APPLIED HERBICIDES FOR INTEGRATED CONTROL OF WATERHEMP IN SOYBEAN. Sean Evans and Gordon Roskamp, Crop Systems Educator and Professor of Agriculture, University of Illinois Extension and Western Illinois University, Macomb, IL 61455.

Within the last decade, adequate control of common waterhemp in soybean has deteriorated in many regions of Illinois. The development of resistance to protox-inhibiting herbicides, increasing tolerance to glyphosate products, prolific seed production, and extended periodicity of waterhemp emergence have been cited as factors contributing to unsatisfactory control. Integrating weed management strategies has been suggested as a means to better manage waterhemp populations, but little research has been directed at testing the application of multiple strategies. Field research was initiated at Macomb, IL in 2003 to compare waterhemp densities and control ratings of 12 soil-applied herbicides (alachlor, metolachlor, metribuzin, metolachlor + metribuzin, metribuzin + flufenacet, flumioxazin, flumioxazin + cloransulam, sulfentrazone, sulfentrazone + chlorimuron, sulfentrazone + cloransulam, dimethenamid, and pendimethalin) applied immediately following planting of narrow-row soybeans at three dates (03-May, 16-May, and 02-June). The experiment was implemented with a factorial arrangement of treatments in a split-plot design with planting date comprising the main-plot factor and soil-applied herbicide comprising the sub-plot factor. Main-plots were arranged in randomized complete blocks with three replications. Tillage was performed immediately prior to planting. All plots were hand-weeded to remove other broadleaf weed species, and clethodim was used to control grasses.

Waterhemp densities in the weedy controls on 18-July, 2003 were 8, 5, and 0.2 plants m^{-2} for the first, second, and third planting dates, respectively. Density counts conducted in early September did not differ from those conducted in early July indicating that most waterhemp present was associated with early emerging cohorts. All soil-applied herbicides provided a significant reduction in waterhemp densities for all three planting dates, but differences in control were evident among herbicides. An overall significant interaction between planting date and herbicide treatment was observed indicating an environmental influence on herbicide efficacy in some instances. Soybean seed yield did not differ among herbicide treatments or planting dates. However, season-long competition with common waterhemp resulted in yield reductions of 23, 9, and 4 percent compared to treated plots for the first, second, and third planting dates, respectively. This research indicates that delayed seedbed preparation associated with later planting in combination with soil-applied herbicides has the potential to increase the likelihood of satisfactory control of waterhemp by dramatically reducing initial populations, especially when used as a component of a two-pass herbicide program.

NEW HERBICIDES FOR WEED MANAGEMENT IN SWEET CORN. Michael G. Particka, Bernard H. Zandstra and William R. Chase, Research Assistant, Professor, and Farm Manager Department of Horticulture, Michigan State University, East Lansing, MI 48824.

The North Central Region of the United States produces approximately 50% of the processed sweet corn in the United States. Sweet corn growers will experience more weed management problems due to weeds developing resistance to herbicides and the loss of registration of current herbicides. New field corn herbicides may replace older chemicals on sweet corn but not all field corn herbicides are safe on sweet corn and differences in tolerance may depend on individual hybrids. Sweet corn herbicide trials were conducted at Michigan State University in 2002 and 2003. One set of experiments evaluated the field corn herbicides flufenacet, mesotrione, pendimethalin, foramsulfuron, halosulfuron, clopyralid, glufosinate, flufenacet+metribuzin, diflufenzopyr+dicamba for safety and effectiveness on sweet corn. The second evaluated combinations of atrazine, mesotrione, and s-metolachlor on ten different sweet corn varieties over two years. Mesotrione at 0.2 lb ai/acre applied PRE caused less than 20% crop injury while providing good weed control. Postemergence applications of halosulfuron at 0.023 lb and clopyralid at 0.188 lb did not provide acceptable control of common lambsquarter. Foramsulfuron at 0.033 lb POST caused less than 20% crop injury and at 0.066 lb caused 25% crop injury while providing good weed control at both rates. Flufenacet alone at 0.6 lb controlled 50% of common lambsquarters in July; but when flufenacet+metribuzin were applied at 0.616 and 0.154 lb, respectively, common lambsquarters control was greater than 90% in July. Pendimethalin provided good weed control when applied alone PRE or POST when tankmixed with atrazine following s-metolachlor. Combinations of atrazine, mesotrione, and s-metolachlor did not cause significant crop injury or reduce marketable ears compared to the untreated control. Ear quality was evaluated by ear length, kernel tip fill, constrictions in the ear, and straightness of kernel rows.

RESPONSE OF SWEET CORN AND POPCORN TO POSTEMERGENCE APPLICATOINS OF FORAMSULFURON. David J. Lamore, Daren Bohannan and Jayla Allen, Technical Service Representative, Bayer CropScience, Research Triangle Park, NC.

Chemical weed control options are limited in commercial sweet corn and popcorn production field. Many of the newer chemistries are not yet registered for use on these crops. Crop tolerance and the high value of these crops, often limits the registration of new products.

Field studies have been conducted in 2000-2003 to determine the tolerance of multiple sweet corn and popcorn hybrids to foramsulfuron + isoxadifen, nicosulfuron, mesotrione, dicamba, and carfentrazone-ethyl. Rates were 37 + 37, 35, 105, 214, and 9.2 grams ai/ha respectively. Foramsulfuron + isoxadifen is a new chemical and safener combination first registered for postemergence applications to field corn in 2002. The potential exists for this chemistry to be expanded into sweet corn and popcorn.

Data generated by university, food processors and industry indicates acceptable sweet corn tolerance to the combination product of foramsulfuron and isoxadifen. Canning hybrids have the highest tolerance. The safening effect of isoxadifen to other chemistries was evident as well. Popcorn tolerance has yet to be properly addressed. Initial injury ratings are high in relation to other products, but recovery is rapid and yields are not effected. Processing hybrids and more tolerant then the more common hybrids. Further evaluations need to be made on both of these crops.

SWEET CORN VARIETAL TOLERANCE TO MESOTRIONE. John Masiunas, Jerry Pataky, Christy Sprague, Marty Williams, and Loyd Wax, Associate Professor and Professor, University of Illinois, Urbana, IL 61801, Assistant Professor, Michigan State University, East Lansing, MI and Research Agronomists, USDA-ARS, Urbana, IL 61801.

New options are needed to manage weeds in sweet corn. Broadleaf weed control in sweet corn relies on applications of atrazine. Several problems exist with the use of atrazine. Important weeds such as *Amaranthus* species and common lambsquarters (*Chenopodium album*) have developed resistance to atrazine. Atrazine can persist, limiting the crops that can be planted the following year. The herbicide has also been found in surface and ground waters. Other registered herbicides such as 2,4-D, halosulfuron, and nicosulfuron can injure sweet corn or varieties vary in their tolerance. Mesotrione may be an alternative to atrazine. The objective of our research was to determine if sweet corn cultivars differ in their tolerance to mesotrione. Approximately 150 sweet corn varieties were evaluated. About 10% of the varieties were extensively injured by mesotrione. Many of the varieties had common inbred parents, suggesting a genetic basis for the susceptibility. Rate responses were conducted for eight cultivars differing in their tolerance to mesotrione. Mesotrione at standard field rates caused greater than 50% injury and reduced yields of Shogun, Gallant, How Sweet It Is, and Polaris. Including atrazine with mesotrione did not increase the injury. GH7749, GH2547, GH2684, and Bonus had less than 10% injury and yields were not reduced. When registered, tt will be necessary to limit mesotrione use to tolerant cultivars.

2003 North Central Weed Science Proceedings 58:195.

SENSITIVITY OF SEVERAL VEGETABLE CROPS TO MESOTRIONE SOIL RESIDUES. Douglas Doohan[1], Joel Felix[2] and Dain Bruns[3], Associate Professor[1], Research Associate[2], Department of Horticulture and Crop Science, The Ohio State University, Wooster, 44691 and Syngenta Crop Protection, Hillard, OH.

Tolerance of red clover, snap bean, cucumber, bell pepper, tomato and cabbage to residues of mesotrione applied to corn the previous year was evaluated at OARDC Wooster and OARDC Vegetable Crops Branch in Fremont. The soil at Wooster was a Wooster Silt Loam with 3% OM and pH of 6 and at Fremont a Colwood Fine Sandy Laom with 3% OM and pH of 5.8. Glyphosate tolerant corn 'Pioneer 599 RR' was seeded following seed-bed preparation on May 10 at Wooster and on May 30 at Fremont. Mesotrione formulated as Callisto was applied PRE at 6, 12 and 24 oz product/A 12 days after seeding at Wooster and on the day of seeding at Fremont. POST applications at 3, 6 and 12 oz product/A were applied 30 and 17 days after seeding, respectively, at Fremont (6 inch corn) and Wooster (4 inch corn). Treatments also include an untreated control and prosulfuron (Peak 0.5 oz product/A POST). A randomized complete block design with 4 replications was used. Plots were 50 X 10 feet. Glyphosate (Roundup UltraMax 1 qt/A) was applied to all plots approximately 1 month after seeding to control weeds not eliminated by treatment herbicides. Grain corn yield was not affected by treatment at either site. Peppers, tomatoes and cabbage were transplanted in late June, to coincide with emergence of clover, beans and cucumbers, seeded approximately 10 days prior. Vegetable crops were drilled in double rows oriented perpendicular to the direction of mesotrione application the previous year. Clover was broadcast seeded in a 4 foot wide bed. Response of clover and vegetable crops was rated visually on the 0-100 scale at 7, 14, 21 and 42 days after emergence/ transplanting. Injury was much more severe at Fremont than at Wooster. At Fremont chlorosis and stunting of clover were apparent within 7 days of emergence and increased with rate. By 28 DAE clover injury in plots treated the previous year with Callisto at 6, 12 and 24 oz/A PRE was 63, 93 and 97%, respectively. Damage to clover at this date in plots treated POST with 3 oz/A of product was similar to injury at 6 oz/A PRE. Snap bean and cucumbers were severely injured by all rates of mesotrione though symptoms took longer to develop than clover. Cabbage, tomato and pepper were more tolerant of mesotrione residues with injury ranging from 5 to 20% 28 DAT. At Wooster clover was only slightly injured by mesotrione applied the previous year and by summer-end was largely indistinguishable from clover in control plots. Cucumbers were only significantly injured when mesotrione had been applied POST at 6 and 12 oz of product/A. Less than 20% injury was noted in snap beans in plots treated the previous year with mesotrione at 6 and 12 oz/A PRE and at 3 and 6 oz/A POST. Cabbage, tomato and pepper at Wooster were nearly free of visual injury symptoms across rates and application timings of the herbicide.

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) applied preemergence and postemergence was evaluated for crop selectivity in sweet corn. Preemergence applications were made using a 32:320:120 g/l mesotrione:s-metolachlor:atrazine co-formulation. Application rates were 2760 g ai/ha on soils having less than 3.0 % organic matter and 3300 g ai/ha on soils with 3.0 % organic matter or more. Postemergence applications were made with a 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. Few negative effects were detected of preemergence applications of the mesotrione co-formulation on sweet corn emergence, early season injury, or yield at harvest. Epinasty was detected on two hybrids at one test location. Postemergence applications of mesotrione + atrazine + COC caused significant injury (bleaching) in some hybrids at some locations. Differences between hybrids within locations were observed. There were also considerable differences between locations in the level of symptoms observed. Sweet corn yields generally were not reduced following postemergence applications of mesotrione + atrazine, regardless of 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.

WEED CONTROL IN PEPPER WITH RIMSULFURON. Joseph G. Masabni, Fruit and Vegetable Extension Specialist, University of Kentucky Research and Education Center, Princeton, KY 42445

An experiment was conducted to test the effects of rimsulfuron 0.031 lb applied pre-transplant (PRT), post-transplant (POT), and post-emergence (PO) on 2 varieties of Bell pepper, Olympus and Wizard. The experiment included other treatments such as trifluralin 1 lb applied PPI, s-metolachlor 1.33 lb applied POT, and halosulfuron 0.032 lb applied PO. Rimsulfuron resulted in non-significant levels of injury and yield reduction to both pepper varieties when applied PRT and POT. Rimsulfuron applied PO following a POT application of s-metolachlor showed little injury and gave the highest yields at levels comparable to s-metolachlor alone. Yields from plots treated with halosulfuron and s-metolachlor were higher than those treated with s-metolachlor alone on one of the 2 varieties tested. Highest level of honeyvine milkweed control was achieved with s-metolachlor applied POT. Johnsongrass and carpetweed were effectively controlled with all treatments that included s-metolachlor, halosulfuron, or rimsulfuron.

WEED CONTROL OPTIONS DURING JUNEBERRY ESTABLISHMENT. Harlene M. Hatterman-Valenti and Paul G. Mayland, Assistant Professor and Research Specialist, North Dakota State University, Fargo, ND 58105.

Field trials were initiated near Absaraka on a Spottswood sandy loam and near Prosper, ND on a Bearden-perella silty clay loam, respectively to evaluate cultural and chemical weed control methods during juneberry establishment. Juneberry seedlings (*Amelanchier alnifolia* L. var. 'Martin') were transplanted June 4 at each location. Chemical treatments consisted of pendimethalin at 1.85, linuron at 1.12, and trifluralin at 1.68 kg ai/ha, respectively. All herbicides were applied prior to transplanting with trifluralin also receiving mechanical incorporation immediately after application. Cultural treatments consisted of black landscape fabric (polypropylene with a polyester blend), black and white plastic (6 mill), ground flax straw (10-15 cm depth), wood chips (10-15 cm depth), mechanical cultivation (rototiller), and a rye cover crop that was planted approximately 15 days prior to transplanting. All cultural treatments except the rye were applied the day after transplanting.

Visual evaluations of crop injury indicated that treatments did not injure juneberry. Timed hand weeding of plots approximately 6 weeks after transplanting indicated that all treatments required less time to weed compared to the untreated control. At Prosper, plots treated with landscape fabric, black plastic, flax, wood chips, and linuron took the least amount of time to weed while at Absaraka, plots with rye and trifluralin took longer for weed removal than other plots. Common purslane was the most prevalent weed at Absaraka followed by redroot pigweed, common lambsquarters, green foxtail, and yellow foxtail. Weed populations were more evenly distributed at Prosper than at Absaraka with yellow foxtail the most prevalent, followed by barnyardgrass, common lambsquarters, green foxtail, redroot pigweed, and common purslane. Black landscape fabric, wood chips, and linuron were the most consistent treatments to reduce weed numbers and dry weight at Absaraka while at Prosper, all treatments except rye, pendimethalin, and trifluralin had similar low weed numbers and dry weights.

Granular matrix sensors and thermisters installed in each treatment at a 15 cm depth, 15 cm from one juneberry stem following weed removal. Plots with poor weed control such as rye and trifluralin became drier than plots with wood chips, flax, landscape fabric, or black plastic. An exception occurred with white plastic. This treatment was consistently as dry as the weedy plots due to weed growth under the plastic. Flax and wood chips moderated soil temperatures more than other treatments with lower average temperatures during July through August and higher average temperatures during September and October.

METOLACHLOR ON SUGARBEET IN EASTERN NORTH DAKOTA AND MINNESOTA. Alan G. Dexter and John L. Luecke, Extension Sugarbeet Specialist and Sugarbeet Research Specialist, Plant Sciences Department, North Dakota State University and the University of Minnesota, Fargo, ND 58105.

Metolachlor was tested for weed control in sugarbeet from 1985 through 1989. The results were encouraging but high levels of metolachlor caused non-cancerous tumors in test animals which prevented metolachlor from being registered for sugarbeet. A change in EPA regulations (revocation of the Delaney Clause) allowed reconsideration of metolachlor and testing on sugarbeet was resumed in 1997. S-metolachlor was registered for sugarbeet in 2003.

Sugarbeet injury evaluated visually averaged 9% in experiments conducted over 29 location-years prior to 2003 from metolachlor at 3.4 kg/ha or S-metolachlor at 2.1 kg/ha. Sugarbeet injury was greater from preplant incorporated metolachlor than from preemergence metolachlor and spring treatments caused more injury than fall treatments.

Visible sugarbeet injury over 20% was observed in only four of 29 location-years and the maximum observed injury was 38% prior to 2003. Sugarbeet injury from S-metolachlor in 2003 was greater than observed in any previous year in experiments. Also, sugarbeet injury from S-metolachlor was widely observed by sugarbeet growers in eastern North Dakota and Minnesota. In 2003 experiments, visible sugarbeet injury averaged 44% and ranged from 20 to 73% from S-metolachlor at 2.1 kg/ha over nine locations. Sugarbeet stand loss averaged 21% and ranged from 0 to 41%. Weed-free sugarbeet treated with S-metolachlor at 2.1 kg/ha yielded 6480 kg/ha of extractable sucrose while sugarbeet treated with ethofumesate at 3.9 kg/ha yielded 8240 kg/ha of extractable sucrose at St. Thomas, ND. Sugarbeet injury was 43% and stand loss was 32% from S-metolachlor at St. Thomas. Rainfall was frequent and widespread after sugarbeet seeding in 2003 and cool temperatures slowed sugarbeet emergence. Moist soil plus slow emergence may have increased movement of S-metolachlor into emerging sugarbeet and increased sugarbeet injury as compared to previous years.

HERBICIDE FORMULATION COMPARISON IN SUGARBEETS. Abdel O. Mesbah, Stephen D. Miller and Craig M. Alford, Research Scientist, Professor, Research Scientist, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Field experiments were conducted in 2003 at Two locations; Powell and Torrington Research and Extension Centers, Wyoming to evaluate weed control and sugar beet response to standard and isopherone-free formulations of desmedipham, desmedipham+phenmedipham, and desmedipham+phenmedipham+ethofumesate. Both formulations were applied three times starting at sugar beet cotyledon stage with 7-day interval between applications using full or micro-rate systems. Very little difference was recorded between isopherone-free and standard formulations concerning weed control at both locations. At Powell, no sugar beet injury was caused by either formulation. However, at Torrington slight sugar beet injury was caused by both formulations of desmedipham (3 to 5%) and desmedipham+phenmedipham+ethofumesate (2 to 3%) when used at full rate. Sugar beet yields and sugar content were similar between formulations.

2003 North Central Weed Science Proceedings 58:201.

PERFORMANCE OF NEW ISOPHORONE-FREE SUGAR BEET HERBICIDE FORMULATIONS.

Dean W. Maruska, Kevin B. Thorsness, Michael C. Smith, John O. Martin, George Simkins, Mary D. Paulsgrove and James J. Cappy, Field Development, Technical Service Representatives and Product Development Managers, Bayer CropScience, Research Triangle Park, NC 27709.

Several widely used sugarbeet herbicides are formulated using the solvent isophorone. Isophorone is a List 1 inert ingredient due to reported carcinogenicity properties. In 2001, EPA issued an extensive data call-in for isophorone to the chemical manufacturers and pesticide registrants that market products containing isophorone. The tolerance-exemption reassessment process for isophorone required under the Food Quality Protection Act is to be completed by August, 2006. Significant time and resources to support the continued use of isophorone in the sugar beet herbicides would be required. Additionally, the use of isophorone containing herbicide formulations will not be permitted in Canada beginning in 2004.

Bayer CropScience has developed isophorone-free formulations of their desmedipham and phenmedipham containing sugar beet herbicides. These new products have been extensively tested in large field trials under an EPA granted Experimental Use Permit in seven sugar beet producing states. The new products provided equivalent to improved crop safety and weed control when compared to the current isophorone containing commercially available products.

LOOKING BACK AND MOVING FORWARD: RESULTS OF NCWSS EXTENSION SURVEY. Shawn P. Conley, Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211.

Time, personnel, and budget constraints within University systems and industry has significantly affected Weed Science Extension programs in the North Central Region. To successfully meet the needs of our clientele we must continue to evolve. The objectives of this symposium were to develop a baseline of information on current NCWSS Extension programs, to discuss methods and ideas for positioning ourselves for the future, and to stimulate ideas and partnerships based on current innovative and successful programs. Input collected at the 2002 NCWSS Extension business meeting was used to develop an on-line survey to determine a baseline of information regarding current extension programs. This survey was sent to all Extension Weed Scientists in the North Central Region. The following is a compilation of information collected from the 13 respondents. Based on survey results respondents believe that our strength lays in developing and delivering unbiased, research based information to our clientele. We also feel that that we must continue to develop educational materials on basic weed science principles as well as technical information regarding herbicide resistance management and genetically modified organisms. Conversely, respondents agreed that we need to increase our efforts in extension education and research on cropping systems management and on integrating disciplines (agronomy, plant pathology, entomology, plant breeding and biotechnology). We also need to increase or efforts in meeting the needs of our part-time and organic clientele. Respondents collectively indicated that the most critical issues facing our discipline were a loss of faculty positions, a general lack of funding, and a perceived de-emphasis on extension programming and applied research by University administration. In the future, respondents indicated that we must continue to develop hands-on in-field training, but we must also work towards developing web-based programs that are centrally located (either one-website within a University or possibly one regionalized website) and that are easy to access by our clientele in the field. Though times are challenging it is apparent that Weed Science Extension Specialists are working to evolve their extension and research programs to meet the changing needs of their clientele.

EXTENSION INTO THE 21ST CENTURY: IMPLICATIONS FOR WEED SCIENCE EXTENSION PROGRAMS. Larry W. Turner, Associate Dean for Extension and Associate Director, Cooperative Extension Service, College of Agriculture, University of Kentucky, Lexington, KY 40546.

Weed Science Extension efforts of the future will be influenced and affected both by changes in the discipline of weed science and by changes in the approach and philosophy of Extension education. With respect to Extension, significant changes are occurring in the focus of programs, clientele demographics, budgetary support, and methods for reaching an ever-changing audience. However, a constant which remains as valid today as it was nearly 100 years ago is that the mission of Extension is to "bring the university to the people" where they live and work and to "make a difference" in the lives of people. Staying relevant and executing that mission in today's Extension environment means connecting with new sources of information across the campus and elsewhere, integrating a broad range of disciplines, and reaching new audiences in new and different ways.

The discipline of weed science also faces changes, as shifts occur from a focus on weed management through herbicide development and application, to a more integrated, biology-based, agro-ecosystem approach to weed management. The advent of biotechnology and its subsequent impact on crop production and weed management approaches also has a significant influence on the demand for and the approach to Extension weed science programming. Further, as with Extension overall, the audience for weed science Extension programming is changing. Fewer traditional, full-time production farmers are in need of Extension weed science programming, while a larger number of part-time farmers, urban gardeners, and ecology-focused end users will be the target audience of the future.

The following is a non-exhaustive list of trends that will affect future Extension weed science programs and approaches:

- Shift from herbicide focus to integrated, biology/ecology based weed management
- Application of biotechnology to crop production and weed management
- Team approach to solutions for complex problems
- Shrinking base of full-time agricultural producers and changing demographics
- Increasing reliance on grant funding, fee-based systems, and other non-formula funds
- Regionalization of approach to Extension programming
- Electronic delivery of information tailored to individual needs
- Globalization of agriculture
- Increased societal concerns regarding food safety and food source
- Concerns for maintenance of biodiversity
- Desire for "natural"/ biological approaches over chemical weed management
- Increasing complexity of problems and the resulting solutions required

Extension is needed now more than ever. The programs that remain viable and of increasing value to clientele are those that will become more flexible, responsive and targeted toward today's and tomorrow's clientele needs. Extension professionals must become more entrepreneurial, and must develop integrated approaches to educational programming addressing complex problems in a meaningful way, providing relevant educational programming to a broader clientele. In the same way, Extension weed science programs have the potential to meet even greater needs in the future with the rapidly changing demands of clientele, increasingly complex problems associated with rapid changes in technology, and a desire for society at large for ecologically sound and "natural" approaches over chemicals. However, weed scientists will need to adapt new techniques, partner outside their discipline, and become part of broader teams to address the issues society identifies as most important relevant to the weed science discipline.

FUTURE OF EXTENSION WEED SCIENCE PROGRAMS – AN INDUSTRY PERSPECTIVE.
Dennis W. Belcher, Technical Service Representative, BASF Corporation, Columbia, MO 65202.

This paper discusses the future of Extension Weed Science programs from an industry perspective. The ag-chemical industry has gone through significant changes in the past 5-7 years and that trend is expected to continue in the foreseeable future. The US herbicide business has changed significantly and, as a result, significant changes have occurred in industry interactions with the extension weed groups. Fewer people, fewer companies, fewer new compounds, and decreased funding have resulted.

A survey was sent to 24 different companies to determine opinions on the future role of Extension Weed Science programs. The survey results indicated that in regard to communications with industry that web-based tools, crop conferences, email updates and print materials were the most effective methods of communication. The survey also indicated that Extension Weed Science does an excellent job of handling current weed related issues, providing useful websites, and hard copy recommendations; and the areas needing improvement were better economic support for weed control recommendations, being more proactive on key topics and improving communication in a time of decreased funding.

The survey also identified weed resistance, economically based weed control recommendations, weed biology and inter-disciplinary weed control approaches as the top research topics for the immediate future. The top clients that should be addressed were identified as the very large farmer, crop consultants, and part-time farmers.

There are still many issues that require Extension Weed Science attention, but there has been a paradigm shift. Extension Weed Science should focus their efforts differently than what has been done in the past. The first major task should be to define the new vision of Extension Weed Science. Because funding is reduced in many areas, reliance on other “influencers” (retailers, consultants, county extension personnel) is critical. There may be an even greater need for Extension Weed Science now than in the immediate past. The same number of acres is being farmed with a greatly reduced number of agronomic and pest management advisors. Weed Science Extension programs have the opportunity to be firmly established as the center for information for the network of individuals working in applied agriculture in the US.

FUTURE OPPORTUNITIES AND STRATEGIES TO SERVE EXTENSION CLIENTELE. Christy L. Sprague, Assistant Professor, Department of Crop and Soil Sciences, Michigan State University, E. Lansing, MI 48824.

The model of an extension specialist in weed science has changed substantially over the last three decades. No longer are the days of face to face meetings with growers in every county of a state. In fact, counties in many states have moved away from having agricultural agents or even providing agricultural programming. Additionally, where there once was a strong agricultural chemical industry we have seen a considerable decline in the number of companies and personnel that used to provide a substantial role in training and support of the agricultural clientele. With this downsizing in personnel in both the public and private sectors, there are many gaps that need to be filled. These gaps leave tremendous opportunities for extension weed scientists, may be even making our roles more important than they have been in the past. So as extension weed scientists, how do we fill these gaps and best serve our clientele? In order to answer this question, we first need to identify who our clientele is and what they need. I believe that we all think that our ultimate clientele is still the grower. Now how the information is disseminated to the grower is different than it has been in the past. Many times, this information is not coming directly from extension weed scientists, but from agrichemical dealers and agronomists. Getting the appropriate information and recommendations to these advisors is important. With fewer extension specialists how do we disseminate this information? Methods of dissemination have become increasingly important. This is the information age; we need to provide timely, accurate, cost-effective information to clientele. We have been able to do this in more recent years through the use of the world-wide-web. This technology has given us access to growers and other clientele that we otherwise wouldn’t have been in contact with. However, not everyone has access to this technology. Are there other methods of information delivery and training that we can use? Balancing dissemination methods is important in not to leave out any clientele. There are other technologies, such as distance learning that have also made extension programming effective to large audiences without having to travel to several distant locations. As extension weed scientists we need to be open minded and adopt some of these newer technologies to better serve out clientele.

FUNDING AND NETWORKING STRATEGIES FOR EXTENSION WEED SCIENTISTS. James J. Kells, Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

The discipline of weed science has experienced and will likely continue to experience a dramatic reduction in funding from the private sector. In addition, faculty positions in weed science at public universities are likely to decrease over the next several years with faculty retirements and reallocation of funds to other university initiatives. With diminishing resources, universities will very likely establish regional alliances to share faculty expertise across state lines. These trends will require extension weed scientists to seek creative ways to remain effective and relevant. Extension weed scientists should work to strategically develop complimentary expertise on a regional basis. With diminishing private sector support, extension weed scientists need to explore other funding sources. Potential funding sources include commodity groups, foundations, and regional and national competitive grant programs. USDA Competitive Grant Programs such as Crops at Risk (CAR), Risk Avoidance and Mitigation Program (RAMP), Organic Transition (OT), and Pest Management Alternatives Program (PMAP) are viable funding sources which have not been fully utilized. Although the emphasis of these programs is usually research, they all require that projects include an outreach (extension) component. Regional programs such as North Central Integrated Pest Management (NC-IPM) and North Central Sustainable Agriculture Research and Education (NC-SARE) are important potential sources for research and extension funding. In order to be competitive for these funds, collaboration will be needed among weed scientists regionally and with other crop and pest management disciplines.

CAN A CORN IPM SURVEY GUIDE EXTENSION PROGRAMMING? Chris M. Boerboom, Richard T. Proost, Adam D. Jacobs, Michael D. Peterson, and Peter J. Nowak, Professor, Regional Agronomist, Graduate Assistants, and Professor, Department of Agronomy and Department of Rural Sociology, University of Wisconsin, Madison, WI 53706.

Assessing clientele needs is the initial step of successful extension programming. Farmers frequently request practical solutions for weed management. However, these requests do not identify barriers to improve integrated weed management (IWM) or if these barriers differ among clientele groups. To understand the rationale for management decisions of Wisconsin corn farmers, we conducted a survey of their practices and perceptions of pest management. A random sample of 667 corn and dairy farmers were surveyed on weed management practices and their use of consultants. The farmers based their response on their most productive corn field in 2001. The survey's final response rate was 35%.

One goal of extension weed management programming is to increase the adoption of IWM. Although scouting was practiced by most farmers (72%), the survey indicated limited adoption of several IWM practices. Of the surveyed farmers, cultivation was used by 34%, application of reduced herbicide rates was used by 8%, and banded herbicide applications, altered row spacing or crop density were used by less than 5%. Crop rotation was used by 56% of the farmers, but crop rotation was used more frequently by corn farmers than dairy farmers and is likely a mere function of their cropping system. Herbicide rotation was used by 34% of farmers.

The specificity in weed management programs and potential for higher levels of IWM may depend upon who is making the herbicide recommendation and application. On average, farmers used self and custom applications about equally. Corn farmers self-applied more herbicides than dairy farmers. Of farmers using custom applicators, barriers to increase the frequency of self-application include time constraints by 76%, not owning equipment by 52%, and a belief that custom applicators can make more accurate applications by 47%. About half to two-thirds of farmers who self-apply herbicides believe custom application is too expensive, that they can better monitor when and where herbicides are applied, and that they lack trust in the timing or location of custom applications. These responses indicate that farmers value self-application of herbicides as a practice to manage risk and expenses. Alternatively, 65% of farmers using custom application trust the timing of application and 56% value the record keeping service provided by their applicator. Only 29% viewed scouting by the custom applicator as a reason for using their service. If thorough scouting is to increase as a component of IWM, the main barriers are the perception of the high cost and that additional profit is not guaranteed. Dairy farmers feel a greater return is required from scouting to justify the expense than corn farmers. Alternately, farmers who use scouting services cite several economic and management benefits for scouting, which could be communicated to non-users.

Changing farmer's attitudes about weed management should improve IWM adoption. Survey results suggest extension programs could focus on weed interference and population dynamics based on perceptions of the effect of early and late season weed competition and the long-term effects of weed escapes. The use of reduced herbicide rates was not perceived to be excessively risky and may be another area of emphasis. Farmers tended to believe that herbicide resistant crops could augment resistant weed problems and that the introduction of new herbicides will not be a solution to resistance. This may indicate that programming on resistance has been partially effective although there is still potential for improvement in the response ratings. Farmers select weed management programs based primarily on control and risk of crop injury and rank price as less influential. Interestingly, a guaranteed re-spray program was an important criteria for selecting a program for only 26% of farmers. The largest advantage for herbicide resistant hybrids that was cited was improved weed control by 67% and largest disadvantage cited was marketing genetically modified corn by 57%. The survey information will be valuable in defining extension weed management programs in the future.

2003 North Central Weed Science Proceedings 58:209.

WEEDSOFT®: A WEED MANAGEMENT DECISION SUPPORT SYSTEM AND TEACHING TOOL. Alex R. Martin*, Professor, Department of Agronomy and Horticulture, University of Nebraska, P.O. Box 830915, Lincoln, NE, 68583-0915.

WeedSOFT® is a Windows based weed management decision support system developed for use in seven North Central states. This effort resulted in each cooperating state having a version of WeedSOFT®, that addresses its unique soil and climatic conditions, weed species and crop production practices. This regional project involves Illinois, Indiana, Kansas, Michigan, Missouri, Nebraska and Wisconsin. WeedSOFT® consists of three modules, Advisor, EnviroFX, and WeedVIEW. Advisor supports preemergence, postemergence and pre + postemergence weed management decisions in four crops: corn, sorghum, soybean, and wheat. EnvironFX supports site and herbicide specific assessment of groundwater contamination potential. WeedVIEW provides visual images as an aid in weed identification.

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

WeedSOFT® is useful in a teaching environment. Learning modules addressing Postemergence Application Timing, Weed Seedbanks, and Environmental Factors have been included in the 2004 version of WeedSOFT®. Among the biological principles that can be illustrated using WeedSOFT® are: differences in competitiveness of different crop species and weed species, the influence of weed and crop growth stage on crop-weed interference, and the influence of production practices including crop row spacing on crop competitiveness. The influence of environmental factors including soil properties and precipitation pattern on herbicide efficacy and risk to rotational crops can be systematically illustrated with WeedSOFT®.

TRANSLATION AND EXTENSION OF WEED INTERFERENCE INFORMATION TO THE PRACTICAL END USER. William G. Johnson, Assistant Professor, Purdue University, W. Lafayette, IN 47907.

One of the biggest challenges faced by extension personnel is finding pertinent weed interference information that has practical implications and can be understood by lay personnel. A substantial number of weed interference studies published 1960’s, 1970’s and 1980’s focused on the interference or competitive effects of a single weed with a crop. These studies provided a wealth of information on growth, development, and fecundity of a specific species and their influence on crop yield based on density and/or emergence times (cohort). These studies were typically very labor intensive and allowed weed scientists to evaluate the relative competitiveness and competitive indices of various species. However, the practical application of this information to the crop advisor or farmer was limited because weed densities in these studies were relatively uniform and weed infestations typically found in production fields include a mixture of species and emergence timings.

More recently, many Universities have been involved in studies that have evaluated the influence of weed removal timing of mixed weed populations on crop yields. This effort was driven in part by availability of newer, broadspectrum postemergence herbicides (particularly ALS inhibitors) in the early 1990’s and crops resistant to imidazolinone, glufosinate, and glyphosate in the late 1990’s. These studies are valuable in that they better mimic real field situations with mixed weed species and emergence timings. They also require much less labor then the single weed studies mentioned above and allowed researchers to collect information from more site-years. The limitation with these studies is that weed densities tend to vary between plots and yield variability within a treatment is typically higher that that observed in single weed interference studies.

The challenge to extension specialists and educators is to assimilate this information into modules, presentations, or publications which can be used to educate lay personnel about the various aspects of weed interference, how weed species differ in their competitive effects on crop yields and environmental influences on weed interference. An informal survey of extension weed specialists revealed the following perceptions and information needs: First, many extension specialists perceive that weed thresholds have little value to the crop advisor, consultant or farmer because of clean-field guarantee programs by basic manufacturers, the expectation that the herbicides applied will control all weeds, and the ease of the glyphosate-resistant crop technology. Second, most felt that that the same individuals could be better informed or could better utilize information about critical periods of control to minimize yield loss rather than late-season field aesthetics. Third, the extension specialists’ biggest challenge in extending weed interference information to end-users is the fact that it is somewhat difficult to make this information as interesting as a new herbicide presentations, and the fact that there is little economic incentive for this clientele to learn this information because of farmer expectations and guarantee programs. Several individuals mentioned that computerized weed management decision aids that utilize a bioeconomic yield loss model such as WeedSOFT were very helpful in educational settings. In addition several mentioned that seasoned clientele were interested in how environmental factors, irrigation and row spacing influences weed interference.