PRESIDENT'S COMMENTS - A YEAR TO REMEMBER. Jerry Doll, Extension Weed Scientist, Department of Agronomy, University of Wisconsin, 1575 Linden Dr., Madison, WI 53706.

2004 was a memorable year for the NCWSS in many ways and the same is certainly true for me as well. The Society represents nearly as many family as professional dimensions for me and this was never more true than during the past year. It felt like a family because the excellent cooperation of fellow officers, directors and committee chairs made the activities of the year flow smoothly and kept the Society fully alive in all our important areas. And it was again professionally rewarding as our summer and fall events are highlights of the year for me. Thanks to all who gave of their time and energy to make this a reality. I've appreciated the opportunity to work with, be stimulated by, and learn from all of you. Let me thank a few people by name as they represent why this was a "Year to Remember" for me.

The event that took us into new waters in 2004 was having the Summer Contest hosted by the University of Minnesota - the first time we have ever held the weed contest at a university site. Bev Durgan and her colleagues did an outstanding job of continuing the tradition of this event being one of the highlights of the year for those who participate, both for students and for all who work to set up and run the contest. Christie Sprague, chair of the Resident Education committee, collaborated with the students and others to review the contents and activities of the Summer Contest and worked diligently with her vice-chairs to see that all the contests functioned smoothly and I and the Society thank her and the entire Resident Education committee and its subcommittees for a job extremely well done.

Bill Johnson, our Communication Editor, and Glenn Nice are to be commended for continually working to improve the NCWSS newsletter and web site and for establishing the list serve feature that allows us to easily communicate to our members and among the leadership groups of the Society. I have no doubt that this will become an even more valuable tool for us in the year ahead. Glenn also gives excellent service to the Society by chairing the Electronic Communications committee which will soon become a standing committee of the NCWSS. Glenn and his committee ensure that the presentations at our sessions are seamless and I have no doubt that they will succeed once again in accomplishing this feat in Columbus.

Michael DeFelice also deserves recognition by the Society. Mike launched the new version of the Interactive Encyclopedia of North American Weeds and, while this is a project of the Southern Weed Science Society, he and the SWSS invited the NCWSS to promote and sell the DVD with a generous portion of the proceeds remaining with our Society. This excellent product will show our commitment to weed science education and also improves our bottom line!

The biggest challenge the Society continues to face is declining membership and participation at our annual conference. We are not alone in this and indeed all the weed science societies are in some stage of reassessing their mission and plans for the future. I commend Duane Rathmann (chair of our Long Range Planning Committee; and Bryan Young, Kassim Al-Khatib, Wayne Fithian and Tom Peters for their efforts in leading us into a strategic planning process coordinated by the Council for Agricultural Science and Technology. The CAST project of "Shared Leadership" is a wonderful way for us to participate in a constructive and guided process to determine who we want to be as a Society and setting plans to take us there. You will see the initial efforts in this regard during our annual meeting and 2005 will be one of much activity in this area. All members are encouraged (and will be invited) to let the Board of Directors know your thoughts and ideas about the future of our Society and our activities. As I reviewed older proceedings of our Society, I was intrigued by how little the purpose of the society has changed. In nearly 60 years of existence, the original purpose has changed only by a few words! Indeed it's time to review, revise and modernize our mission and be proactive in planning.

Tom Peter's, our Program Chair, has convened an excellent set of presentations for our general session that will help us think creatively and critically about our future. He and the Mark Loux, Local Arrangements Chair, are to be commended for working diligently to ensure a successful and smoothly conducted annual meeting in Columbus.

As we look to the future, we should review our past as well. We have an excellent resource to do this in the 1989 publication, "The North Central Weed Control Conference: Origin and Evolution" edited by Bob Anderson. It covers all the years from the beginning of our Society in 1944 until we changed our name to the North Central Weed Science Society in 1988. I reviewed parts of our history prior to this meeting and encourage you to do the same. Some of the questions we ask today regarding our discipline in general and our Society in particular have been with us for many years! Next year will be our 60th anniversary. We may want to celebrate in a special way our past as we venture into new areas in the future.

Thank you for allowing me to serve as president of the NCWSS. It has truly been a year to remember. The Society has effectively served our discipline and members for many years. I have no doubt that it will continue to fulfill a useful role for years to come. With Tom Peters, Steve Miller and Adrian Moses in the leadership chain and numerous dedicated Board and committee members in our Society, we have proven leaders who will serve us well and ensured that we will have many more "years to remember."

ITALIAN RYEGRASS CONTROL IN WINTER WHEAT. Dallas E. Peterson, Scott Gordon, Gary L. Kilgore, and Kenneth W. Kelley, Professor, Montgomery County Extension Agent, Professor, and Associate Professor, Kansas State University, Manhattan, KS 66506.

A field experiment was conducted in southeast Kansas to evaluate fall and spring postemergence herbicide treatments for Italian ryegrass control in '2174' hard red winter wheat seeded on October 27, 2003. Fall postemergence treatments were applied to 2-leaf wheat and 1- to 2-leaf Italian ryegrass on November 21. Spring postemergence treatments were applied to tillered wheat and Italian ryegrass on March 19, 2004. The experiment was a randomized complete block design with three replications. Wheat injury and ryegrass control were evaluated through the season and wheat was harvested for grain yield. Fall and spring treatments with mesosulfuron or mesosulfuron plus propoxycarbazone, and fall applications of chlorsulfuron plus metsulfuron or diclofop gave near complete control of Italian ryegrass. Italian ryegrass control was better with fall than spring treatments of chlorsulfuron plus metsulfuron, diclofop, tralkoxydim, sulfosulfuron, and propoxycarbazone. Several treatments caused minor wheat stunting, which diminished over time. Wheat yields and foreign matter content generally corresponded to Italian ryegrass control. Wheat yield was increased by as much as 40% by controlling Italian ryegrass in the fall.

TOLERANCE OF POPCORN TO VARIOUS HERBICIDES. Thomas T. Bauman, Michael D. White, and Chad D. Dyer, Professor, Research Associate, and Graduate Student, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN, 47907.

Between 70,000 and 80,000 acres of popcorn are grown in Indiana each year. The number of herbicides available for popcorn producers to use is limited. To provide producers with more weed control options we have evaluated mesotrione and foramsulfuron for possible use in popcorn.

Four different popcorn hybrids with different genetic make ups were tested to determine whether crop response and yields were affected by the different weed management systems. The herbicides were tested at the labeled dent corn rate and were applied to ten inch popcorn. Both herbicides were tested alone and as tank mixes. Different adjuvant systems were also tested. These herbicides were compared to several industry standard post emergence herbicides.

Both mesotrione and foramsulfuron caused injury seen as bleaching and stunting of the crop. The impact of this early season injury depended upon environmental conditions and popcorn hybrid. Even if the popcorn recovered from the early season injury, it might deter many producers from using these herbicides.

HYBRIDIZATION BETWEEN A HERBICIDE TOLERANT WHEAT VARIETY AND JOINTED GOATRGRASS IN THE CENTRAL GREAT PLAINS. W. Brien Henry[1], T.A. Gaines[2], P.F. Byrne[3], D.L. Shaner[4], S.J. Nissen[3] and P.A. Westra[3]. [1]Weed Scientist, USDA-ARS, Central Great Plains Research Station, Akron, CO. [2]Graduate Student, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO. [3]Plant Physiologist, USDA-ARS, Water Management Unit, Fort Collins, CO. [4]Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State.

Jointed goatgrass (JGG, *Aegilops cylindrica*) is a troublesome weed in wheat fields of the Central Great Plains. Wheat and JGG share the D genome, thus providing a basis for genetic exchange between the two species. Although wheat-JGG hybrids are known to occur in the Central Great Plains, the frequency of cross-pollination and the distance over which such crosses occur has not been reported for this region. We took advantage of a newly released wheat variety tolerant to the herbicide imazamox to estimate wheat-JGG cross-pollination between adjacent plants and between plants up to 6 m apart. JGG seed was collected, planted in flats, grown to the 2-leaf stage and sprayed with the recommended rate of imazamox. Survivors were sprayed a second time to confirm their herbicide tolerance, and the percent surviving plants was used as an estimate of cross-pollination. Results and implications of the study will be presented.

EFFECT OF IMAZETHAPYR AND IMAZAPYR ON POLLINATION OF IMIDAZOLINONE TOLERANT CORN. James H. Herbek, James R. Martin, and Jonathan D. Green, Extension Professors, Department of Agronomy, University of Kentucky, Princeton, KY 42445.

Occasional problems in seed-set have occurred with imidazolinone tolerant corn treated with postemergence applications of the premix of imazethapyr at 0.672 oz ai/A plus imazapyr at 0.224 oz ai/A. Symptoms of deformed ears varied from twisted rows, pinched ears, scattered kernels, to barren ears. It has been debated how this injury is related to the pollination process and whether such factors as environment, application timing, and hybrid play a role in this problem.

The 2002 study involved foliar applying the premix on three hybrids at 3, 4, and 5 weeks after crop emergence. Anther emergence had completed before a visual evaluation of corn tassels could be made; however, general field observations indicated the amount of “spent” anthers that dropped from the tassel on corn leaves and on the soil surface was noticeably less only where Pioneer 34B28 was treated at 5 weeks after plant emergence. Plants for this hybrid were at the V9 growth stage and had an average height of 42 inches when treated.

It was decided to continue research efforts with emphasis on timing of application only on the Pioneer 34B28 hybrid. The study in 2003 involved applying the permix at 3, 4, 5, and 6 weeks after crop emergence. Average corn height was 11, 17, 24, and 32 inches, respectively; whereas, corn growth stage was V4, V5, V6, and V8, respectively. A visual estimate of the percent of tassel occupied by emerged anthers on ten consecutive plants was made on July 3, 2003. The estimates for plants treated at corn growth stages V4, V5, V6, and for the non-treated check ranged from 34 to 44% and were statistically equal but greater than the 4% observed for plants treated at V8 growth stage. A visual rating of ear deformity was made at corn harvest on Sept 3, 2003 and was based on anomalies from tip to butt of the ear. Although no statistical differences in ear deformity occurred, the percent of deformed ears tended to be greater for plants treated at V8 growth stage compared with those from the other treatments. Corn yields for all treatments in 2003 were equal, consequently, they did not correlate with difference in emerged anthers on tassels.

The emphasis of the 2004 study was to limit the application timing to V8 growth stage, since this appeared to be the optimum stage for achieving a response in regards to inhibited anther development / emergence. It was also decided to increase size of plots and buffer areas in an attempt to limit drift of pollen from non-treated corn to treated corn. The size of plots for the 2004 study was doubled by increasing the length from 25 feet to 50 feet and increasing the buffer areas on each side of plots from 4 rows to 16 rows. Also, the corn planted in the buffer areas was delayed approximately 3 weeks to insure that pollen development in the buffer strips would be delayed and not coincide with silk development / receptiveness in the treated areas. The premix was applied to Pioneer 34B28 corn when plants averaged V8 growth stage at a plant height of 29 inches. This occurred at approximately 5 weeks after corn emergence. Anther emergence, silk development, and ear deformity were monitored in a flagged area of each plot consisting of ten consecutive plants occurring in each of the two center rows of the treated and non-treated plots. Daily ratings of the percent of the central tassel spike occupied by emerged anthers were made from June 22 through July 4, 2004. These results indicated a delay in anther development and fewer emerged anthers in the treated corn compared with the non-treated corn. By July 4, 2004 the estimates were 25% for the treated plants and 98% for the non-treated plants. The fact the length of ear silks on July 4 were nearly twice as long in the treated corn than in the non-treated corn suggested that pollination may have been limited in the treated corn. However, observations of ears of mature plants indicated that pollination and fertilization did occur in the treated plots. A rating for ear deformity, based on twisted rows or pinched ears, indicated up to 10% deformity for treated plants. The magnitude of ear deformity was less than expected based on the differences in anther and silk development between treated and non-treated corn. Therefore, increasing the size of plots and buffer areas may not have limited the risk of cross- pollination from occurring in the 2004 study.

In summary, the premix of imazethapyr plus imazapyr limited anther emergence / development when applied at the label rate to Pioneer 34B28 at V8 to V9 growth stage. The growth stage of plants may be a better indicator for determining when corn is more prone to injury than height of plants or weeks after emergence. The design of these experiments may not have prevented cross - pollination from occurring.

A COMPARISON OF SAFENERS FOR METOLACHLOR ON CORN. Crystal R. Schulz, James J. Kells, and Donald Penner, Undergraduate Research Assistant and Professors, Department of Crop and Soil Science, Michigan State University, East Lansing, MI 48824.

A field study was conducted in 2004 to compare the safeners benoxacor and dichlormid for efficacy in safening the unresolved isomeric mixture of metolachlor on an inbred corn line. Benoxacor is currently marketed in combination with both the unresolved isomers of metolachlor and the resolved s-metolachlor. Previous research has shown that the safener dichlormid to be an effective corn safener for alachlor and acetochlor on corn. Metolachlor was applied preemergence alone and in combination with benoxacor or dichloramid at rates of 2.24, 4.48, 8.96 kg ai/ha. Corn injury was determined based on visual observation and stand loss at 7, 14, 21, and 28 days after emergence (DAE). At 7 DAE metolachlor applied at rates pf 4.48 and 8.96 kg ai/ha caused significant injury compared to corresponding rates with either safener. Metolachlor in combination with benoxacor at rates of 4.48 and 8.96 kg ai/ha resulted in significantly less injury than the same rates of metolachlor combined with dichlormid. The results of this study indicates that both benoxacor and dichlormid increase corn tolerance to metolachlor.

GROWTH REGULATOR INDUCED ROOTLESS CORN RESULTING FROM PREEMERGENCE APPLICATIONS OF 2,4-D AND DICAMBA. Kevin L. Hahn, DuPont Ag and Nutrition, Bloomington, IL 61704.

Rootless corn, floppy corn, and high crown syndrome are terms that are often used to describe situations in which corn plants have had problems developing secondary (nodal) roots. This results in corn plants lodging at about V3 to V8 growth stages. Several factors have been identified as possible causes of rootless corn. These include shallow planting, planting in loose fluffy soils, poor seed furrow closure, cloddy or compacted soils, etc. Personal observations during service calls and the ability to recreate rootless corn with preemergence applications of plant growth regulator herbicides 2,4-D and dicamba in research and demonstration plots has shown that these herbicides can cause rootless corn syndrome by inducing a hyper-elongation of the of the mesocotyl which places the nodal roots at or above the soil surface.

GIANT RAGWEED MANAGEMENT IN HERBICIDE RESISTANT CORN. Michael D. White, Thomas T. Bauman, and Chad D. Dyer, Research Associate, Professor, and Graduate Student, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN, 47907.

Giant ragweed is one of the most competitive annual weeds in corn and can cause significant reductions in crop yield. In addition to competition it also can harbor insect pests such as stalk and corn borers.

Giant ragweed was one of the first weeds in Indiana to evolve resistance to herbicides classified as ALS inhibitors. Many herbicides labeled for giant ragweed control in corn are ALS herbicides. Effective alternative control measures need to be identified for control of giant ragweed if the prevalence of ALS resistant giant ragweed increases. Several herbicide resistant crop management systems were tested to determine their effectiveness in controlling giant ragweed in corn. The herbicide resistant crop systems tested were Roundup Ready, Liberty Link and Clearfield. Effective giant ragweed control was obtained with weed control programs which utilized sequential applications of glyphosate and glufosinate and tank mixes of glyphosate, glufosinate and imazethapyr+imazapyr with atrazine, dicamba and mesotrione.

A NEW APPROACH TO COLLABORATIVE PEST MANAGEMENT RESEARCH USING TRANSGENIC CORN. Kathrin Schirmacher, James J. Kells, Christina D. DiFonzo, and Scott M. Swinton, Graduate Student, and Professor, Department of Crop and Soil Sciences, Associate Professor, Department of Entomology, and Professor, Department of Agricultural Economics, Michigan State University, East Lansing, MI 48824-1325.

Transgenic traits offer corn growers new options for weed and insect management. Stacking both insecticide and herbicide resistance traits into a single corn hybrid offers new strategies for pest management in Michigan corn production. These technologies will be aggressively marketed in the near future. Adoption of these new technologies will only occur if there is a clear economic advantage over current practices. There will be many questions regarding the economic value of these traits.

The objectives of this project are: (1) to design and conduct field experiments to identify the conditions in which the cost of multiple transgenic traits are justified in relation to conventional practices, and (2) to disseminate the results of the experiments to farmers and farm advisors.

This research involves weed science, entomology, and agricultural economics. A field experiment was designed and conducted in 2004 at four locations with differing weed and corn rootworm infestations. Near-isogenic corn hybrids were selected containing either the glyphosate resistance trait or both glyphosate resistance and corn rootworm resistance. Weed control comparisons included one preemergence and two postemergence herbicide strategies. Corn rootworm strategies included the resistant hybrid, a conventional soil-applied insecticide, and seed treatment. The experiment will be repeated in the 2005 and 2006 growing seasons.

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

Weed removal timing in corn is critical to minimize competition for available resources such as nitrogen. The objective of this experiment was to compare weed removal timing to in-season corn leaf nitrogen and resultant grain yield. Field studies were conducted in 2003 and 2004 in central and northeast Missouri. Corn 'Asgrow RX730' was planted in late April in 76 cm rows at a population of 69,500 seeds/ha. Weed removal treatments were timed for different sizes of grasses only (4), broadleaves only (4), and a mixed population of grasses and broadleaves (6). Grass only plots were established with early POST applications of 2,4-D , and grasses were removed at heights ranging 12 to 32 cm. Broadleaf competition was achieved by a PRE application of *s*-metolachlor; broadleaves were removed at heights ranging from 8 to 23 cm. POST glyphosate applications were used to remove weeds and additional applications were made to maintain weed-free conditions. This study was established as a randomized complete block design with four replications. A chlorophyll meter (Minolta® SPAD 502) was used to record corn leaf nitrogen at 10-day intervals in selected treatments from the initial timing of weed removal until plant senescence. For each site-year, SPAD meter readings were lowest for the untreated control, and readings were highest for the weed-free control. SPAD meter readings declined generally following 90 to 100 days after planting, reflecting leaf and plant senescence. Early season SPAD meter readings were similar between the 25 cm grass, 32 cm grass, and 20 to 25 cm broadleaf treatments, indicating few differences in the competition for available nitrogen. SPAD meter readings were up to 29 % lower for the weed removal treatments versus the weed-free control. Grain yield was reduced up to 92 % for the untreated control versus the weed-free control. In all 4 site-years, grain yield was similar for treatments with single and sequential applications of glyphosate, compared to the weed-free control, provided applications were made before weeds reached 15 cm in height. Also, grain yield reductions due to competition from the largest broadleaves (20 to 25 cm) were minimal. However, grain yield was 4 to 16% greater when broadleaves were removed initially at 5 to 10 cm compared to 20 to 25 cm in height. Grass pressure reduced yield up to 17% when glyphosate application was delayed until grasses reached 30 cm compared to the weed-free control. Grain yield was optimal when grasses were removed at 12 cm compared to delaying the removal until 30 cm. Reductions in corn leaf nitrogen reflected reduced grain yield from competition with weeds, but the availability of other factors, such as water, were also important.

RIMSULFURON PLUS GLYPHOSATE FOR ONE PASS WEED CONTROL IN GLYPHOSATE TOLERANT CORN. J. Leslie Lloyd*, James D. Harbour and David W. Saunders. DuPont Ag & Nutrition, Johnston, IA 50131.

Studies were conducted in 2000 - 2004 comparing herbicide systems in glyphosate tolerant corn (Zea mays L.). Glyphosate applied alone early and mid postemergence was compared to tank mixtures of glyphosate and rimsulfuron. 68 studies were placed in replicated small-plot trials with university, private contractor and DuPont investigators. Additional trials were conducted in field-scale plots in commercial fields. Key weeds included giant foxtail (Setaria faberi L.), yellow foxtail (Setaria glauca L.), fall panicum (Panicum dichotomiflorum L.), common lambsquarters (Chenopodium album L.) and several amaranthus species. The addition of rimsulfuron to glyphosate improved season-long control of several grass and broadleaf weed species. Rimsulfuron provided residual activity on many grass and small seeded broadleaf species and improved the burndown efficacy of glyphosate on several broadleaf species.

COTTON RESPONSE TO SIMULATED DRIFT RATES OF SEVEN HORMONAL-TYPE HERBICIDES. Kassim Al-Khatib, Douglas E. Shoup, Dallas E. Peterson, and Mark M. Claassen, Professor, Graduate Research Assistant, Professor, and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66502.

Cotton response was evaluated when 2,4-D amine, 2,4-D ester, clopyralid, picloram, fluroxypyr, triclopyr, and dicamba were applied at rates simulating spray drift during the 6 to 8 leaf stage at Manhattan and Hesston, Kansas in 2004. Herbicide rates applied represented 0, 100^{-1}, 200^{-1}, 300^{-1}, and 400^{-1} of the use rates of 561, 561, 280, 561, 210, 561, and 561 g ha^{-1} for 2,4-D amine, 2,4-D ester, clopyralid, picloram, fluroxypyr, triclopyr, and dicamba, respectively. Injury from 2,4-D amine and 2,4-D ester were similar and was greater than that of other herbicides. The order of phytotoxicity was 2,4-D>picloram>dicamba>fluroxypyr>triclopyr>clopyralid. All herbicides caused characteristic symptoms of hormonal-type herbicide, except triclopyr and clopyralid which caused severe bleaching and chlorosis. By 56 days after treatment, no injury symptoms were observed on plants treated with all herbicides except, all rates of 2,4-D, the three highest rate of picloram, and the highest rate of dicamba. All rates of 2,4-D and the two highest rates of picloram, and dicamba caused severe flower abortion. This research clearly showed that cotton is extremely susceptible to simulated drift rates of 2,4-D.

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GLYPHOSATE RESISTANT HORSEWEED CONTROL WITH POSTERMEMERGENCE HERBICIDES IN CORN AND SOYBEAN. William G. Johnson, Reece A. Dewell, Vince M. Davis, and J. Earl Creech. Assistant Professor, Research Associate, Graduate Research Assistant, and Graduate Research Assistant, Department of Botany and Plant Pathology, Purdue University, W. Lafayette, IN 47907.

Field studies were conducted to evaluate late postemergence treatments for glyphosate-resistant horseweed control in emerged, glyphosate-resistant soybean and corn at the Southeast Purdue Agricultural Center near Butlerville, IN, on a Clermont silt loam soil with 1.3% organic matter. Treatments were arranged in a randomized complete block with four replications and applied with a CO_2 backpack sprayer calibrated to deliver 15 gallons per acre when horseweed ranged from 1 to 12 inches tall.

In the corn study, horseweed control with glyphosate (0.77 lb ae/A) alone was less than 45% at 18 DAT. Control was 80% with atrazine + mesotrione, halosulfuron + dicamba (Yukon), dicamba + atrazine, and prosulfuron + primisulfuron (Spirit). At 89 DAT, control with the glyphosate alone treatment was less than 75%; however, a number of treatments provided greater than 90% control. Treatments which provided greater than 90% control at the end of the season included atrazine, atrazine + mesotrione, dicamba + diflufenzopyr (Distinct), primisulfuron + dicamba (Northstar), primisulfuron + prosulfuron, dicamba + diflufenzopyr + nicosulfuron (Celebrity Plus), halosulfuron, halosulfuron + dicamba, dicamba + atrazine, metribuzin, flumetsulam, flumetsulam + clopyralid (Hornet). Products containing atrazine, dicamba, metribuzin, primisulfuron + prosulfuron, and flumetsulam provided the best overall control.

In the soybean study, glyphosate alone at 0.77 lb ae/A provided 46, 60, and 69% control, respectively, at 18, 32, and 89 DAT. Glyphosate alone at 1.12 lb ae/A provided 76, 90, and 95% control, respectively, at 18, 32, and 89 DAT. Horseweed was controlled 88% or higher at all three rating dates with cloransulam alone. Chlorimuron alone controlled horseweed 81 to 84% at all three rating dates. 2,4-DB alone provided poor control. The addition of chlorimuron or cloransulam to glyphosate usually resulted in better control than glyphosate alone. The addition of 2,4-DB to glyphosate did not improve control, and may have resulted in reduced control in a couple of instances. Three-way mixtures of glyphosate + chlorimuron + 2,4-DB controlled ERICA 83 to 96% at all three rating dates. Three-way mixtures of glyphosate + cloransulam + 2,4-DB controlled ERICA 69 to 97% at all three rating dates. Although the three way mixtures tended to provide good control at all three rating dates, crop injury concerns with 2,4-DB might limit it’s use. The addition of chlorimuron or cloransulam to glyphosate appears to be the best tankmix partner for control of glyphosate resistant horseweed if it is not ALS resistant..

CONTROL OF STAR-OF-BETHLEHEM PRIOR TO CORN AND SOYBEAN. Jennifer A. Hagerman and Bryan G. Young. Graduate Research Assistant and Assistant Professor, Plant, Soil and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901.

Star-of-Bethlehem is an emerging weed problem in no-till agricultural fields and pastures. Research was conducted to evaluate the efficacy of glyphosate, 2,4-D, and paraquat applied at three rates each for preplant control in no-till crop production. Herbicides were applied on April 11, 2002 and again on April 18, 2003 to the same respective plots as in 2002. Star-of-Bethlehem plants were 15 to 20 cm in height at each application. Visual evaluations were taken 14 days and approximately one year after herbicide application. In April, 2004, star-of-Bethlehem bulbs were collected from soil samples at a depth of 7.6 cm.

Following the first application of herbicides, control of star-of-Bethlehem at 14 days after treatment (DAT) was 97% or greater with paraquat. Glyphosate and 2,4-D, controlled less than 55% of star-of-Bethlehem at 14 DAT, regardless of herbicide rate. Star-of-Bethlehem control one year after the 2002 herbicide application (prior to 2003 herbicide application) was 70 to 89% with paraquat and less than 29% from glyphosate and 2,4-D. Control of star-of-Bethlehem following the second application of paraquat was 99% for all herbicide rates, 14 DAT. The second application of glyphosate and 2,4-D controlled less than 63% of star-of-Bethlehem regardless of herbicide rate. Two consecutive preplant applications (2002 and 2003) of paraquat resulted in 95% or greater control of star-of-Bethlehem, whereas glyphosate and 2,4-D controlled less than 18% of star-of-Bethlehem when evaluated one year after the second application.

The total number of star-of-Bethlehem bulbs collected in the nontreated plot in 2004 was 6,248/m^2. Paraquat reduced the bulb density by 88% compared with only a 5% reduction for glyphosate. Conversely, the sequential application of 2,4-D resulted in a 15% increase in the bulb density compared with the nontreated. Thus, paraquat is more effective than glyphosate or 2,4-D for both short-term and long-term management of star-of-Bethlehem in no-till preplant applications.

FIELD SURVEY OF WEEDS OBSERVED IN KENTUCKY BEFORE AND AFTER WIDESPREAD ADOPTION OF GLYPHOSATE-TOLERANT SOYBEANS. T. Saphangthong*, M.W. Marshall, J.D. Green, and J.R. Martin. Graduate Research Assistant, Research Specialist, Extension Professor, Extension Professor, Department of Agronomy, University of Kentucky, Lexington, KY 40546-0312.

Over 80% of the soybean acres are now planted with varieties containing the Roundup Ready® technology that are glyphosate-tolerant. Field surveys were conducted initially in ten counties during 1998 and 1999 before the widespread adoption of glyphosate-tolerant soybeans in Kentucky. Field surveys were repeated in seven counties during 2004 to determine if adoption of this technology has resulted in a shift in the composition of weed species observed in soybean production. Fields were surveyed at 3 to 5 weeks after planting. Ideally this would allow time for weeds to emerge after crop planting, but before a field was treated with an in-season postemergence herbicide, such as glyphosate. The field scouting method involved recording all weed species present at a survey point. Survey sites were determined by walking in a S-shaped pattern by counting the number of paces that divides a field into five acre segments. Since the survey sites were within each five acre segment, this field survey method provided a technique for determining the frequency of occurrence for each weed species observed by calculating the number of survey sites it occupied to the total number of sites surveyed within each field. The relative frequency of occurrence of the weed species observed within a county or for a state-wide summary could also be calculated by using this survey method. Sixty-four different soybean fields representing approximately 2,730 acres were surveyed during 1998 and 1999. A total of 30 fields representing approximately 1,680 acres were surveyed in 2004. Nearly all fields surveyed have been in a corn-soybean or corn-wheat-soybean rotation. Because of this crop rotation with corn, most fields had been in soybean production only 3 of the past 6 years. For the 2004 survey, glyphosate-tolerant soybean varieties had been grown 3 or more years in 21 of the 30 fields surveyed. Ninety-seven different weed species were observed in soybean fields across Kentucky with initial survey during 1998 and 1999. Prickly sida, johnsongrass, honeyvine milkweed, wild garlic, and ivyleaf morningglory were among the top five most frequent species observed (≥22% of the sites surveyed). The remaining top ten species included smooth pigweed (21%), volunteer wheat (20%), pitted morningglory (18%), trumpetcreeper (16%), and horseweed (16%). In 2004, one-hundred different weed species were observed in 2004. Horseweed, smooth pigweed, johnsongrass, common pokeweed, and prickly sida were among the top five most frequent species observed (≥20% of the sites surveyed). The remaining species in the top ten included dandelion (19%), fall panicum (18%), trumpetcreeper (17%), pitted morningglory (16%), and eastern black nightshade (16%). When comparing the two survey periods, the presence of horseweed increased from the tenth most common species (16% of the field sites surveyed) in 1998 and 1999 to the most frequently observed species (36%) in 2004. Furthermore, horseweed was observed at 50% of the survey sites in the 21 fields which have been planted with glyphosate-tolerant soybean for at least 3 years while horseweed was only found in 16% in fields with less than 3 years of glyphosate-tolerant technology. In all fields surveyed, the other weed species that increased were common pokeweed (21%) and dandelion (19%). However, presence of prickly sida declined sharply from 36% in 1998 and 1999 to 20% in 2004. Johnsongrass also declined to 23% of the survey sites in 2004 from 34% in the previous survey, but it remained in the top three most observed weeds. Weed species that also declined include honeyvine milkweed, ivyleaf morningglory, yellow nutsedge, and large crabgrass. Other species that remained nearly the same in frequency of occurrence across both survey periods and occupied 10% or greater of the survey sites included smooth pigweed, fall panicum, trumpetcreeper, pitted morningglory, eastern black nightshade, and hophornbeam copperleaf.

A SIMPLE PESTICIDE ASSESSMENT GUIDE FOR 595 PEST MANAGEMENT PLANS. Richard T. Proost, Chris M. Boerboom and Patrick A. Murphy, Senior Outreach Specialist, Nutrient and Pest Management Program, Professor, Department of Agronomy, University of Wisconsin, Madison, WI 53706 and State Resource Conservationist, Natural Resources Conservation Service, 8030 Excelsior Drive, Suite 200 Madison, WI 53717-2906.

The United States Department of Agriculture-Natural Resources Conservation Service (NRCS) has a long history of providing cost-share dollars to farmers for the implementation of soil conservation practices. The NRCS has expanded cost-sharing into the crop production areas of nutrient (NRCS 590 standard) and pest management (NRCS 595 standard). Cost-sharable plans must be written by an NRCS Technical Service Provider (TSP), an accreditation many agricultural consultants currently hold. A required component of the NRCS 595 pest management standard is an environmental risk analysis of the pesticides incorporated into the pest management plan. The pesticide risk analysis is completed by the TSP writing the plan and requires the use of the NRCS Windows Pesticide Screening Tool (WIN-PST) or other NRCS-approved risk analysis tools. The current WIN-PST model is a complex computer program that requires user training in order to run and interpret program output. Because of this, an effort was made to develop a quicker, alternative method of providing the required risk analysis based on WIN-PST output that could be used in the field or in the office.

A WIN-PST pesticide risk analysis takes user supplied data and calculates eight hazard ratings on the potential for pesticide loss and risks to human and fish health. Hazards ratings have risk categories of very low, low, intermediate, high and extra high. Hazard categories of intermediate, high or extra high are of particular importance as they require mitigation techniques incorporated into the pest management plan that reduce the risk potential. The first step of the development project simplified hazard ratings by grouping them into two easily understood ratings; pesticide risk to groundwater and pesticide risk to surface water. As individual hazard ratings were grouped, the highest risk category within a group of ratings was used as that group’s rating. This was done to preserve the meaning of the WIN-PST output.

The second step of the development project was to conduct a sensitivity analysis of WIN-PST output using 10 pesticides with dissimilar chemical properties on 30 Wisconsin soil types with dissimilar physical properties. Sensitivity analysis indicated that soils could be grouped into five categories based on soil formation characteristics while maintaining the integrity of WIN-PST hazard ratings. Information from the first and second steps was presented to NRCS and Wisconsin Department of Agriculture, Trade and Consumer Protection specialists who approved its use for pest management planning in Wisconsin.

The result of this project was the creation of the Wisconsin WIN-PST Risk Assessment Quick Guide, a five page document containing hazard ratings for 107 pesticides (54 herbicides, 31 insecticides and 22 fungicides) that represent 90% of all pesticides applied to Wisconsin farmland. While the Wisconsin WIN-PST Risk Assessment Quick Guide is only valid in Wisconsin, this process could be repeated in other states for developing a simplified pesticide assessment tool.

THE INFLUENCE OF COMMON WATERHEMP GROWING CONDITIONS ON THE EFFICACY OF GLYPHOSATE APPLICATIONS. Julie M. Young, Scott A. Nolte, and Bryan G. Young, Researcher, Graduate Assistant, and Associate Professor, Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901.

Research was conducted in the field and greenhouse in 2004 to evaluate the influence of shade, intraspecific weed competition, and herbicide placement on target leaves for control of common waterhemp with glyphosate. In field studies, artificial shade and intraspecific plant competition were imposed on common waterhemp to determine if these factors influence growth rate and subsequent control with glyphosate. Common waterhemp plants in high densities (intraspecific competition) and under shade grew taller at a faster rate than other plant growing conditions. Common waterhemp in the shade had a higher maximum photosynthetic efficiency than plants in full sun for two days. Plants in high densities under shade had the lowest photosynthetic efficiency of all herbicide treated plants at 7 days after treatment, suggesting that these plants were more sensitive to glyphosate.

In the greenhouse, glyphosate was applied in a factorial arrangement of treatments with the two factors consisting of light exposure (shade and full sun) and herbicide placement (whole plant and top half of plant). Similar to the field study, plants under shade had a higher maximum photosynthetic efficiency (prior to herbicide application) compared with plants under full sun. Visual control and dry weight data indicate that control of common waterhemp under full sun was greater when the whole plant was treated compared with the top half only. However, control of common waterhemp plants under shade was similar regardless of what portion of the plant was treated.

2004 North Central Weed Science Proceedings 59:22.

ALFALFA RESPONSE TO TRIBENURON. Lisa M. Dahl, Kirk A. Howatt, and Dwain W. Meyer, Graduate Assistant, Assistant Professor, and Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105-5051.

Field research was conducted in Fargo and Leonard, ND, in 2004 to determine the effect of tribenuron application rate and timing on established alfalfa (*Medicago sativa* L.). Tribenuron, a sulfonylurea herbicide that inhibits acetolactate synthase in the branched-chain amino acid synthesis pathway, is not registered for use in alfalfa. However, tribenuron is used in cereal crops to control broadleaf weeds such as Canada thistle, dandelion, and Russian thistle. Treatments were applied with a CO_2-pressurized backpack sprayer delivering 80 L/ha to the center 2 m width of 3- by 9-m plots. To evaluate tribenuron use rates, tribenuron was applied at 4.2, 8.4, 17, 34, and 68 g ai/ha with 0.25% v/v NIS to 4 to 5 cm of alfalfa growth after dormancy break and to 4 to 5 cm of regrowth after first harvest. Imazamox was applied at 35 g ai/ha with 1.7 L/ha methylated seed oil and 2.3 L/ha urea and ammonium nitrate solution as a commercial standard, and an untreated control was included. At both locations, the first tribenuron application resulted in as much as 23% chlorosis. The lowest tribenuron rate, 4.2 g/ha, resulted in 10% chlorosis. The second tribenuron application caused similar injury symptoms ranging from 10% chlorosis at 4.2 g/ha to 25% chlorosis at 68 g/ha. At the Leonard location, first harvest alfalfa yields were reduced 40 to 67% after tribenuron application. The Fargo location showed 37 to 80% reduction of first harvest yields after tribenuron application. Second harvest yield reduction ranged from 67 to 87% at Leonard and 64 to 93% at Fargo. To evaluate application timing, tribenuron at 8.4 and 17 g/ha was applied to 0, 2, 5, and 10 cm of regrowth after first harvest. Imazamox and an untreated control were included as previously described. Tribenuron at 8.4 g/ha resulted in as much as 18% and 15% chlorosis at Leonard and Fargo, respectively. Depending on application rate and time of application, first harvest yields were reduced 59 to 77%. Second harvest yields were reduced 31%. All combinations of tribenuron rate and application timing resulted in substantial yield loss for the harvest following tribenuron application.

METSULFURON METHYL AND CHLORSULFURON: COMBINATIONS THAT PROVIDE POSTEMERGENCE WEED CONTROL IN IMPROVED PASTURES AND RANGELAND. Michael T. Edwards *, Robert N. Rupp, Eric P. Castner, James D. Harbour, C. William Kral, Lawrence S Tapia, Field Development Representatives, Product Development Manager, DuPont Crop Protection, Lakewood, CO 80228

Metsulfuron methyl and Chlorsulfuron are combined in different products to provide residual postemergence weed control in pasture and rangeland. Combinations of metsulfuron methyl, 2,4-D amine and dicamba (Cimarron Max), and combinations of metsulfuron methyl and chlorsulfuron (Cimarron X-tra) are new product offerings from DuPont Crop Protection that in replicated field trials have measured grass response and weed control in improved pastures and rangeland.

Research has shown excellent results on annual and perennial broadleaf weeds including musk thistle, Scotch thistle, Canada thistle, fringed sagebrush, sand sagebrush, kochia and Russian thistle. Multi-year studies continue to show biomass reduction of prickly pear, brittle cactus and yucca. Ongoing clipping studies continue to have a 1 to 3-fold forage increase in grass forage when metsulfuron methyl and chlorsulfuron combinations are used.

HERBICIDE JOINT ACTION RESPONSES OF PPO INHIBITOR-RESISTANT AND SUSCEPTIBLE WATERHEMP BIOTYPES. 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.

Since 2001, waterhemp populations from several counties in Illinois have been confirmed resistant to protoporphyrinogen oxidase (PPO)-inhibiting herbicides. To further complicate management, many PPO inhibitor-resistant waterhemp populations are also resistant to acetolactate synthase (ALS) inhibitors and triazines. As multiple herbicide resistance continues to spread among Illinois waterhemp populations, the number of chemical options for waterhemp control will concomitantly decrease. Realizing that herbicides with novel sites of action are not likely to be commercialized in the near future, our objective is to examine the potential for the joint action of existing herbicide chemistries to improve the control of PPO inhibitor-resistant waterhemp populations. Herbicide combinations were identified based on those products producers currently use, and those that have the potential to act synergistically. Herbicide joint action responses were analyzed using the additive dose model based on the calculation of GR_{50} (growth reduction by 50%) rates for each herbicide. Herbicide combinations tested included PRE applications of clomazone and sulfentrazone, and various POST combinations that included lactofen, carfentrazone, bentazon, or mesotrione. Additionally, the use of sequential applications of lactofen or acifluorfen is being evaluated as a possible control strategy for PPO inhibitor-resistant waterhemp. Results thus far suggest that a PRE-applied combination of clomazone and sulfentrazone acts synergistically in PPO inhibitor-resistant waterhemp, but not in the susceptible waterhemp biotype.

DIFFERENTIAL RESPONSE OF COMMON RAGWEED TO GLYPHOSATE. Justin M. Pollard*, Brent A. Sellers, and Reid J. Smeda, Graduate Research Assistant, Post Doctoral Research Assistant, and Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211.

Glyphosate is a broad-spectrum herbicide that is utilized on greater than 80% of the soybean production area in the United States. Much of the soybean production area currently receives two or more applications of glyphosate per year. In 2002, a population of common ragweed was discovered in Missouri that was inadequately controlled following six years of glyphosate applications. Common ragweed seedlings were established in the greenhouse, and when plants reached 6 nodes they were treated with technical grade potassium salt of glyphosate. Application rates varied from 1/16X to 12X (1X=0.84 kg ae/ha) for the suspect resistant population, and 1/256X to 1X for the susceptible population; surfactant (MON 56151) was added to each spray solution at a rate equivalent to that of a 1X Roundup WeatherMax™ application. Applications were made with a moving track sprayer at 187 L/ha with a spray pressure of 167 kPa. Ammonium sulfate was added to all treatments at 2.8 kg/ha. The above ground tissue was harvested four weeks after treatment and plant dry weights recorded following 4 days at 50 C. The suspect resistant population exhibited an I_{50} value that was 9.6-fold higher than the susceptible biotype on a dry weight basis. Preliminary results from an in vivo shikimate assay demonstrated that differences in shikimate accumulation were up to 3-fold greater for the susceptible compared to the resistant common ragweed population. Although heritability of this trait has not been established, these data suggest that the suspect population is likely resistant to glyphosate.

IN VITRO SELECTION OF DNA APTAMERS AGAINST TOBRAMYCIN. Nick Coleman, Jie Zhu and Balazs Siminszky, Research Analyst, Graduate student and Professor, Agronomy Department, University of Kentucky, Lexington, KY 40546-0312.

Aptamers are small, single-stranded DNA or RNA molecules that can specifically bind to a target. Developed in the 1990s, aptamers have been soon recognized as powerful research tools due to their wide target range, high-affinity target binding, exquisite specificity, great structural stability and simple production, features that allow the selection of aptamers for most proteins and a wide range of small molecules quickly and economically. While aptamers found several practical applications in biomedical and basic biochemical research, their potentials in agrochemistry, environmental toxicology and pesticide physiology have not yet been tested. In recent years our laboratory has been involved in developing aptamers against small molecules with the ultimate goal of selecting ssDNA aptamers against pesticides. To optimize the selection process, we chose tobramycin, an aminoglycoside antibiotic, as one of our targets. Tobramycin is substituted with 5 amino groups that carry positive charges under physiological pH and facilitate the immobilization of the molecule to solid support, features that render tobramycin an ideal target for aptamer selection. We immobilized tobramycin to an agarose matrix and performed the SELEX procedure to isolate the ssDNA aptamers that specifically bind to tobramycin. After 12 selection cycles, the complexity of the ssDNA pool was reduced to a single DNA sequence that displayed affinity to tobramycin. Our future direction is to evaluate the feasibility of using the anti-tobramycin aptamers as solid-phase extraction matrices for tobramycin detection. The results of these experiments will be used to extend this technology to research in the areas of herbicide safeners and pesticide residue analysis.

EMERGENCE AND CONTROL OF CUT-LEAF TEASEL WITH POSTEMERGENCE HERBICIDES. Diego J. Bentivegna and Reid J. Smeda. Graduate Research Assistant and Associate Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211.

The genus *Dipsacus* includes the weedy species commonly known as teasel. The prominent species in the US are cut-leaf (*Dipsacus laciniatus*) and common teasel (*Dipsacus fullonum*). These species were introduced into North America from Europe, and are proliferating along roadsides. Teasel is a biennial; reproduction occurs only by seed. Biology studies were established to determine the periodicity of teasel emergence; herbicide efficacy studies were also established to identify optimum management practices. Teasel emergence was monitored monthly after fall 2003 establishment of 2000 seeds in 1.5 by 1.5 m plots. The majority (+98%) of teasel emerged in April or October, with approximately 110 to 115 seedlings per m^2; minimal emergence occurred the rest of the year. To evaluate herbicide efficacy, two sites were selected along highway corridors in central Missouri. Fall applied treatments were made in 3 by 6 m plots, and included glyphosate at 2.52 kg ai/ha, 2,4-D amine at 1.68 kg ai/ha and dicamba + diflufenzopyr at 0.29 kg ai/ha. After initial growth commenced the following spring, these same treatments were applied in addition to 2,4-D + triclopyr at 2.52 kg ai/ha, 2,4-D + picloram at 2.13 kg ai/ha, 2,4-D + clopyralid at 2.01 kg ai/ha, metsulfuron-methyl at 0.008 kg ai/ha, sulfosulfuron at 0.11 kg ai/ha, paraquat at 0.94 kg ai/ha, imazapyr at 0.84 kg ai/ha and sulfometuron-methyl at 0.11 kg ai/ha. An untreated control was also included. The experiments were established as a randomized complete block design with four replications. Visual evaluation of herbicide applications in the fall were made 15, 30 and 60 days after application. For spring applications, visual evaluations were made for newly established and 1 year rosette plants. To assess residual activity, two 0.3 by 0.3 m quadrants were established for the treatments of 2,4 D + picloram, dicamba + diflufenzopyr, metsulfuron-methyl, paraquat, and imazapyr, with seedling emergence counted monthly. For fall application, plant injure increased from 67% in the fall to more than 90% the following spring for glyphosate, 2,4-D amine, and dicamba + diflufenzopyr. In the spring, non-residual postemergence herbicides such as glyphosate or paraquat had better performance overall 15 days after treatment compared to the other herbicide treatments. Sulfosulfuron did not control teasel. In general, dicamba + diflufenzopyr, metsulfuron-methyl and imazapyr had better and more consistent control 60 days after of spring treatment (>85% biomass reduction). Control of plants at 60 days after treatment application was greater than 85% for all treatments except paraquat, sulfometuron-methyl and sulfosulfuron. Imazapyr and 2,4-D + picloram provided the best control (>86%) of seedling teasel 60 days following herbicide application; glyphosate and sulfosulfuron resulted in the poorest overall control (< 28%). There were no differences in teasel emergence among plots treated with 2,4 D + picloram, dicamba + diflufenzopyr, metsulfuron-methyl, paraquat, and imazapyr.

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MESOTRIONE CARRYOVER INJURY TO CARROT, ONION, CABBAGE AND CUCUMBER. Darren E. Robinson and John O'Sullivan, Assistant Professor, Ridgetown College, University of Guelph, Ridgetown, ON, N0P 2C0, and Professor, Department of Plant Agriculture, University of Guelph, Simcoe, ON, N3Y 4N5.

The effects of mesotrione residues on visual injury, plant dry weight, and yields varied among various vegetable crops planted one year after herbicide application in field trials conducted in Ridgetown, Ontario and Simcoe, Ontario in 2003 and 2004. In the first year of the study, mesotrione was applied preemergence at rates of 175 and 350 g a.i. ha^{-1}, or postemergence at rates of 100 and 200 g a.i. ha^{-1} to field corn. An untreated, weed-free check was included as a comparison. In the second year of the study, carrot, onion, cabbage and cucumber were planted into the trial area, and maintained weed-free for the entire growing season. Visual injury was measured 7, 14 and 28 days after emergence, dry weights were taken from plants sampled at 28 days after emergence, and final yields were measured for all crops in all treatments. At either location, the order of tolerance was carrot < onion < cabbage = cucumber. In all crops except carrot, significant reductions in biomass were observed. Significant yield reductions were observed in cabbage and cucumber, but not in onion. Onion, cabbage and cucumber should not be grown the year following application of mesotrione. Though dry weight and yield of carrot were not less in any of the mesotrione treatments than in the untreated check, some visual injury was observed. Caution should be used when growing carrot one year after application of mesotrione, depending on differences in weather and soil characteristics.

ADZUKI BEAN: WEED CONTROL AND PRODUCTION ISSUES. Gary E. Powell, Christy L. Sprague, and Karen A. Renner, Research Assistant, Assistant Professor, and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Michigan adzuki bean (*Vigna angularis*) production for southeast Asian export has increased in the past decade. Because of limited herbicide registrations, growers ask questions on weed control and crop tolerance. Field studies were conducted in 2001, 2002, and 2004 to assess crop tolerance, weed control, and control of volunteer adzuki bean in succeeding crops. Herbicides were applied to adzuki bean at rates labeled for dry edible bean or soybean. Adzuki bean injury from preplant applications of trifluralin, pendimethalin, and ethalfluralin was less than 5%, 12%, and 13%, respectively, in 2002 and 2004. Preplant applications of EPTC in 2004 caused 30% adzuki bean injury. Metribuzin and S-metolachlor preemergence resulted in adzuki bean injury ranging from 2% to 20% and 12% to 44%, respectively, in 2001, 2002 and 2004. Injury from dimethenamid-P ranged from 35% to 68% in 2001 and 2004. Injury from alachlor preemergence ranged from 28% to 48% in 2001 and 2002. Imazethapyr + pendimethalin preemergence injured adzuki bean 7%, while imazethapyr preemergence caused 4% adzuki bean injury in 2004. Cloransulam- methyl preemergence injured adzuki bean 12%; while postemergence applications resulted in adzuki bean injury of 24% in 2004. Applications of fomesafen postemergence injured adzuki bean from 14% to 28% in 2001 and 2004. Imazamox applied postemergence injured adzuki bean from 8% to 17%, while addition of bentazon to imazamox increased injury 10% to 15% while increasing control of common lambsquarters. Lack of black nightshade control from metribuzin without a postemergence or tank-mix partner resulted unharvestable treatments. Overall weed control in adzuki bean was consistent with a given herbicides performance in dry edible bean or soybean. Volunteer adzuki bean in a subsequent corn crop was controlled by atrazine + acetachlor (92%), and dicamba + difluenzopyr (95%). Volunteer adzuki bean in soybean was controlled by chlorimuron ethyl + thifensulfuron methyl (90%) and flumioxazin (100%). Sulfentrazone controlled volunteer adzuki bean 75% and reduced seed yield by 85%.

LONG-TERM WEED CONTROL IN APPLE, PEACH, AND BLUEBERRY WITH FALL APPLIED HERBICIDES. Joseph G. Masabni, Fruit and Vegetable Extension Specialist, University of Kentucky Research and Education Center, Princeton, KY 42445.

Flumioxazin (Chateau 51WG) is an herbicide for the preemergence control of broadleaves and grasses. Chateau also has a postemergence activity for the burndown of emerged weeds. Chateau was recently labeled for use in non-bearing fruit trees and bearing grapes. Long-term weed control in apple, peach, and blueberry was investigated following fall application of herbicides.

Treatments consisted of simazine 2.5 lb ai, norflurazon 2 lb ai, napropamide 2 lb ai, and oryzalin 2 lb ai were applied on November 11, 2003. Flumioxazin was also applied at 0.19 and 0.38 lb ai on apple and peach, and at 0.08 and 0.38 lb ai on blueberry. Flumioxazin rates of 0.19 and 0.38 lb ai/A are the labeled rate recommended by Valent Company. All treatments included glyphosate 1 lb ai for burndown control of preexisting weeds.

Weed control evaluation in mid-April or 4 months after application showed that flumioxazin-treated plots had no weeds present and no weeds germinating. Plots treated with napropamide, norflurazon, and oryzalin showed significant regrowth of dandelion, common ragweed, and chickweed. Simazine plots had fewer weeds germinating than the other herbicides.

By early June or 6 months after application, no differences in residual weed control were observed for all treated plots when compared to the control. All plots were equally weedy and required immediate floor management measures. It appears that flumioxazin weed control benefit was exhausted by 6 months after application, compared to 4 months for all other herbicides.

Fall application of flumioxazin can eliminate the need for early spring weed control. This time saved can be spent on other important activities such as pruning and disease and insect control.

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RESPONSE OF PEPPERMINT AND SPEARMINT TO MESOTRIONE AND CLOMAZONE. Mary S. Gumz and Stephen C. Weller, Graduate Research Assistant and Professor, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907.

A critical need in Midwest peppermint and spearmint production is to have access to herbicides that control *Amaranthus* spp. and white cockle. In order to address this need, greenhouse and field trials were conducted to determine the potential of mesotrione and clomazone for safe and efficacious use in peppermint and spearmint.

In greenhouse studies, mesotrione rates of 0, 17, 35, 52, 70, 92, and 105 g a.i./ha were applied pre- and postemergence to peppermint, spearmint, and Powell amaranth. Clomazone was applied preemergence at rates of 0, 420, 840, 1260, and 1680 g a.i. /ha to peppermint, spearmint and white cockle, and postemergence to white cockle rosettes. Both herbicides showed potential to provide weed control with limited crop injury and resulted in the design of field experiments to more specifically determine herbicide rates that provided efficacy and minimal crop injury under Indiana field conditions.

In field studies, mesotrione was applied preemergence at rates of 0, 70, 105, and 210 g a.i. /ha and postemergence at rates at rates of 0, 35, 70, 105, and 210 g a.i./ha (plus 1% v/v COC and 1kg/100L AMS). Clomazone was applied at rates of 0, 210, 420, and 630 g a.i. /ha. Both herbicides were applied at two times during the season, either in the spring or in the fall. Preemergence mesotrione or clomazone was applied prior to weed and crop emergence in the spring and after crop harvest in the fall. Postemergence application of mesotrione was made after crop and weed emergence in the spring and fall. Spring pre- and postemergence treatments of mesotrione caused less injury than fall applications to both peppermint and spearmint. At both timings, peppermint had greater tolerance to preemergence applications while spearmint had greater tolerance to postemergence applications. Twenty-four DAT, the 35 g a.i. /ha preemergence mesotrione had caused no injury when applied in the spring compared to 10% and 15% when applied in the fall on peppermint and spearmint, respectively. Injury 24 DAT from 35 g a.i. /ha postemergence mesotrione was 8.3% in spring peppermint, 12% in fall peppermint, 5% in spring spearmint, and 10% in fall spearmint. *Amaranthus* spp. were controlled (>90%) at all rates by both the pre- and postemergence applications. Although clomazone at most rates caused some initial chlorosis on the mints, by 24 DAT, no injury was apparent on either peppermint or spearmint and clomazone resulted in greater than 90% control of white cockle seedlings and rosettes.

WEED MANAGEMENT SYSTEMS IN CONVENTIONAL AND ORGANIC TOMATO PRODUCTION. David Hillger and Kevin Gibson, Purdue Univ., West Lafayette, IN

The use of on-farm studies provides a view at how management systems impact the weed communities in various farming systems. Clustering farm units into groups with similar management practices allows for the replication of management systems in an on-farm study. The objective of this study is to objectively classify farming units into management systems based on the answers provided in detailed questionnaires. Twenty-four tomato growers provided information about their management practices from 1999 to 2004. Variables derived from the questionnaires are used to describe the management history, nutrient input, herbicide input and tillage of each farm unit. These variables are used in statistical classification techniques to group the farming units into like management systems. The greatest differences in management systems are between the organic fresh market and processing tomato systems.

MULTI-STATE EVALUATION OF SWEET CORN HYBRID TOLERANCE TO HERBICIDES.

Chris M. Boerboom, Roger L. Becker, Martin M. Williams, Robin R. Bellinder, Mark J. VanGessel, and R. Edward Peachey, University of Wisconsin, Madison, WI 53706, University of Minnesota, St. Paul, MN 55108, USDA-ARS, Urbana, IL 61801, Cornell University, Ithaca, NY 14853, University of Delaware, Georgetown, DE 19947, and Oregon State University, Corvallis, OR 97331.

Sweet corn hybrids frequently exhibit differential tolerance to labeled herbicides and herbicides with pending registrations. The sweet corn seed industry and processors are interested in characterizing hybrid tolerance to avoid releasing susceptible hybrids or recommending herbicides that may cause injury. Replicated field evaluations at a single site may offer precision in evaluating injury, but can be costly and do not test the range of environmental conditions that may induce injury. Certain sweet corn seed companies are interested in partnering with universities to improve the efficiency of evaluation trials. This project's goal was to determine the feasibility of a herbicide tolerance evaluation network that is coordinated between seed companies and universities. For this pilot project, seed companies were solicited to determine their interest in providing the logistical support of planting the trials at their existing field stations to reduce costs. University collaborators were also solicited to determine if they would be available to treat and rate the trials. For the pilot project, three companies contributed logistical support and six university colleagues were interested in participating. Because fewer industry stations were volunteered than required, five of the eight trials were conducted on university stations.

Sweet corn tolerance to V3-stage postemergence applications of nicosulfuron and mesotrione was evaluated because differential tolerance is known to exist to these herbicides. Separate trials were established for each herbicide. Twenty hybrids were planted in three ranges of 6-m long single-row plots in a non-randomized strip plot arrangement at each location. The strip plots were re-randomized among locations. The first and third ranges were treated with labeled and twice labeled herbicide rates. The labeled rates were 35 g ai/ha nicosulfuron plus 1% v/v crop oil concentrate and 2.2 kg/ha ammonium sulfate and 105 g ai/ha mesotrione plus 1% v/v crop oil concentrate. The center range was a nontreated control to simplify visual ratings, which were taken at 7, 14, and 28 days after treatment (DAT).

Stunting from nicosulfuron among the 20 hybrids ranged from 5 to 16% at the labeled rate and from 8 to 26% at twice the labeled rate at 7 DAT. Stunting generally declined by 14 DAT and ranged from 0 to 13% at the labeled rate and from 5 to 19% at twice the labeled rate. At 7 DAT, 'Basin' had the widest range in injury among the locations with ratings of 0 to 60% and a mean of 18% injury. A variable response among locations was also noted at 14 DAT where 'Bonus' had the widest range in injury ratings of 0 to 45%.

Chlorosis from mesotrione among the 20 hybrids ranged from 0 to 12% at the labeled rate and from 1 to 26% at the twice labeled rate at 7 DAT. At twice the labeled mesotrione rate, 9 of the 20 hybrids had greater than 10% injury at 7 DAT, but the injury declined rapidly and only one hybrid had 10% injury at 14 DAT. 'Dynamo' had the greatest injury at both rates at 7 DAT and was included in the trials because it can be injured by mesotrione. Among the eight locations, the degree of injury to Dynamo was inconsistent and ranged from 0 to 35% at the labeled rate and from 0 to 60% at twice the labeled rate. The results for both herbicides illustrates the potential benefit of testing tolerance over several locations, which increases the likelihood of encountering environmental conditions that cause injury if a hybrid is less tolerant.

EFFECTS OF PRE-PLANT INTERVAL AND RATE OF TRIBENURON METHYL ON RE-CROPPING SAFETY TO FIELD CORN, SORGHUM, AND SOYBEANS. Marsha J. Martin, Helen A. Flanigan, Larry H. Hageman and David W. Saunders. Field Development, DuPont Crop Protection, E. I. DuPont De Nemours and Co.,Inc.,Wilmington, DE 19898

Nine tests were installed throughout the US to assess pre-plant interval length and the rate of tribenuron methyl on re-cropping safety to field corn, sorghum and soybeans. Applications of tribenuron methyl at 0.125, 0.25, 0.5, and 1.0 ozai/acre were made at 30, 14, 7, 3 and 0 days before planting and irrigated within 48 hours of planting. Plots were kept weed-free with non-ALS chemistry. Crop safety evaluations were made at 14-22, 27-37, and 54-69 days after planting. Grain fill and harvest evaluations were made in August and September.

Based on these evaluations, tribenuron methyl rates up to and including 0.15 ozai/acre could be safely re-cropped to field corn and soybean 7 days after application, whereas rates of > 0.15 ozai/acre up through 0.25 ozai/acre could be safely re-cropped to field corn and soybean 14 days after application. Sorghum results were variable thus further testing is proposed before a re-cropping interval can be determined.

WATER CONDITIONER EFFECTIVENESS IN GLYPHOSATE-MICRONUTRIENT TANK-MIXTURES. Mark L. Bernards, Kurt D. Thelen, and Donald Penner, Research Associate, Associate Professor, Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Application of micronutrient foliar fertilizers in tank-mixtures with glyphosate can increase efficiency in glyphosate-resistant soybean production. However, the prescience of the hard-water cations Ca^{2+} and Fe^{3+}, and the fertilizer Mn^{2+}, in the spray solution have antagonized glyphosate efficacy. In solution, glyphosate is a weak acid and readily forms complexes with cations. When glyphosate complexes with di- and trivalent metal cations, glyphosate absorption into and/or translocation within the plant is reduced. The objectives of this study were to 1) quantify the antagonism caused by cations commonly found in hard-water sources and foliar micronutrient fertilizers, and 2) determine if commercially available water-conditioners were able to eliminate the antagonism.

Velvetleaf and common lambsquarters were grown in 0.9 L pots in the greenhouse. Treatments were applied to 14-cm velvetleaf and 10-cm common lambsquarters using a single tip track sprayer. Treatment solutions were prepared in distilled water. Plants were evaluated visually for control 7, 14, and 21 d after treatment, and were measured for shoot height and weight. All experiments were conducted twice. Data was evaluated against the assumptions of analysis of variance, and then analyzed using the proc mixed procedure of SAS.

Nine salts (aluminum sulfate, calcium carbonate, calcium nitrate, calcium sulfate, copper sulfate, ferric chloride, magnesium sulfate, manganese sulfate, and zinc sulfate) were applied at four different concentrations with a 41% a.i. commercial formulation of isopropylamine-glyphosate (0.45 kg a.e./ha) to determine the cation concentration at which glyphosate efficacy was reduced approximately 50%. The spray volume was 190 L/ha.

Ten water conditioners – AccuQuest (0.5%), ammonium sulfate (1% and 2%), AX0405 (1%), Alliance (0.75%), Choice (0.5%), Class Act Next Generation (2.5%), NTANK (1%), ReQuest (0.5%), Superb (1%), and Surfate (1.0%) – were used in glyphosate tank-mixtures with ferric chloride (160 mg Fe^{3+}/L), manganese sulfate (800 mg Mn^{2+}/L), or zinc sulfate (540 mg Zn^{2+}/L). The glyphosate rate was 0.28 kg/ha, and the spray volume was 90 L/ha.

Velvetleaf was more sensitive than common lambsquarters to the presence of metal cations in glyphosate tank-mixtures. At the rate of 0.4 kg glyphosate/ha, velvetleaf control was reduced approximately 50% at the following cation concentrations: Al^{3+} (200 mg/L), Ca^{2+} (200 mg/L, from nitrate salt), Fe^{3+} (270 mg/L), Ca^{2+} (400 mg/L, from sulfate salt), Mn^{2+} (500 mg/L), Zn^{2+} (540 mg/L), Mg^{2+} (600 mg/L), Cu^{2+} (1600 mg/L). Only Al^{3+} (320 mg/L), Fe^{3+} (400 mg/L), and Ca^{2+} (1600 mg/L, from nitrate salt) reduced control of common lambsquarters 50%. Calcium carbonate did not interact significantly with glyphosate due to poor solubility. The antagonism caused by calcium sulfate decreased as the Ca^{2+} concentration increased above 400 mg/L. This phenomenon may be related to the solubility of calcium sulfate. Glyphosate-metal precipitates formed in the spray solution when Fe^{3+} levels exceeded 70 mg/L, and Al^{3+} levels exceeded 200 mg/L.

The water conditioners evaluated were grouped into three categories. NTANK, AMS, and Class Act Next Generation were the most effective at reducing the antagonism caused by Fe, Mn, and Zn. However, slight but significant reductions in control remained evident for certain water conditioner-cation combinations. Fe, Mn, and Zn in the spray solution caused large reductions in control by tank-mixtures with the least effective water conditioners, AccuQuest, ReQuest, and Choice. Weed control obtained from tank-mixtures with the moderately effective water conditioners, AX0405, Alliance, Surfate and Superb, were intermediate the other two categories.

MANAGEMENT OPTIONS FOR DANDELION CONTROL IN NO-TILL SYSTEMS. Reece A. Dewell, William G. Johnson, J. Earl Creech, and Vince M. Davis, Research Associate, Assistant Professor, Graduate Research Assistant, and Graduate Research Assistant, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Adoption of no-till production practices utilizing 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. Three field studies were conducted near Woodburn, IN to evaluate various herbicide combinations and application timings for fall and spring dandelion control in soybean. Fall treatments were applied on November 17, 2003 and spring treatments were applied between April 1 and May 20, 2004. Soybeans were planted in 15-inch rows on May 6 by the cooperating farmer. A postemergence blanket treatment of glyphosate (Roundup Weathermax) was applied on June 4, 2004 to two of the three study areas. Visual dandelion control ratings and/or dandelion counts were collected several times between April 9 and October 7. In an application-timing study, dandelion control with glyphosate, 2,4-D (ethylhexyl ester), and glyphosate + 2,4-D was most effective with applications prior to flowering (i.e., fall, April 1, and April 10). In this study, glyphosate + 2,4-D consistently provided better control than either product alone across most rating dates. At the May 20 rating, 14 of 15 chlorimuron combinations (fall or spring applications) were providing at least 79% control of dandelion. The only exception was a spring application of 2,4-D + chlorimuron + NIS + AMS (0.5+0.0078+0.25%+2.5 lb/A) which provided 69% control. Other treatments that provided at least 80% control of dandelion at this rating were: fall-applied flumioxazin + dicamba&2,4-D (Range Star) + tribenuron + NIS + AMS (0.064+0.25&0.72+0.0047+0.25%+2.5 lb/A), spring-applied flumioxazin + cloransulam + glyphosate (GF-1279) + 2,4-D + COC + AMS (0.048+0.0157+0.56+0.5+1.0%+2.5 lb/A), spring-applied glyphosate + 2,4-D + AMS (0.77+1.0+2.5 lb/A), and spring-applied glyphosate + flumioxazin + 2,4-D + AMS (0.77+0.064+0.5+2.5 lb/A). On July 1 (27 days after the glyphosate blanket application), 14 of 15 chlorimuron combinations (fall or spring applications) were still providing at least 89% control of dandelion. The exception at this rating was a spring application of flumioxazin + glyphosate (Roundup Original Max) + chlorimuron + NIS + AMS (0.063+0.77+0.0078+0.25%+2.5 lb/A) which provided 83% control. Other treatments providing at least 89% dandelion control on July 1 were: spring applications of glyphosate + 2,4-D + AMS (0.77+1.0+2.5 lb/A), glyphosate + flumioxazin + 2,4-D + AMS (0.77+0.064+0.5+2.5 lb/A), flumioxazin + 2,4-D + NIS + AMS (0.063+0.5+0.25%+2.5 lb/A), flumioxazin + cloransulam + glyphosate (GF-1279) + 2,4-D + COC + AMS (0.048+0.0157+0.56+0.5+1.0%+2.5 lb/A), flumetsulam + glyphosate (GF-1279) + 2,4-D + COC + AMS (0.04+0.56+0.5+1.0%+2.5 lb/A), and cloransulam + glyphosate (GF-1279) + 2,4-D + COC + AMS (0.0157+0.56+0.5+1.0%+2.5 lb/A). October 7 dandelion counts showed that all fall and spring applications reduced the number of dandelions by 50 to 95% compared to nontreated checks, which only received the blanket glyphosate application 4 to 6 weeks after planting.

TOLERANCE OF OTEBO BEAN TO PREEMERGENCE HERBICIDES. Nader Soltani*, Darren E. Robinson, and Peter H. Sikkema. Research Associate, Assistant Professor, and Assistant Professor. Ridgetown College, University of Guelph, Ridgetown, Ontario, Canada N0P 2CO.

Otebo beans are a new market class of dry beans grown in southwestern Ontario. Efficient weed management programs are an important component of profitable otebo bean production. Weeds compete with otebo beans for light, moisture and nutrients, and can drastically reduce bean quality and yield. Weeds present at harvest can interfere with harvesting efficiency, increase mechanical damage to the pods and stain the beans. Otebo bean growers currently have only one herbicide registered for use in Ontario. Lack of registered herbicides means high input costs for cultivation and hand hoeing. In addition, otebo bean yield and quality are reduced. Therefore, there is a great need for new weed control products to keep Ontario otebo bean production competitive.

Preemergence (PRE) application of dimethenamid, S-metolachlor, clomazone, and imazethapyr have been used by growers in other crops to successfully control troublesome weeds such as green, yellow and giant foxtail, barnyard grass, fall panicum, witch grass, large and smooth crabgrass, lady's thumb, redroot pigweed, lambsquarters, velvetleaf, common ragweed, giant ragweed, smartweeds, wild mustard, wild buckwheat, cocklebur, and nightshades. However, there is little information on the tolerance of otebo beans to these herbicides under Ontario environmental conditions. Expanding the registration of these herbicides will provide otebo bean growers with additional control options for grass and broadleaf weeds. Research has shown that tolerance of dry beans to various herbicides is largely dependent on rate, cultivar, and environmental conditions.

The objective of this research was to determine the tolerance of otebo beans to the PRE application of dimethenamid, S-metolachlor, clomazone, and imazethapyr.

Field trials were conducted at four Ontario locations in 2003 and 2004 to evaluate tolerance of otebo beans to the PRE application of dimethenamid (1250 and 2500 g ai/ha), S-metolachlor (1600 and 3200 g ai/ha), clomazone (1000 and 2000 g ai/ha), and imazethapyr (75 and 150 g ai/ha).

Dimethenamid caused as much as 4, 3, and 1% visual injury and S-metolachlor caused as much as 5, 3, and 1% visual injury at 7, 14, and 28 days after treatment (DAT), respectively. However, these injuries were transient with no adverse effect on plant height, shoot dry weight, seed moisture content and yield of otebo beans. Clomazone caused as much as 13, 13, and 9% visual injury at 7, 14, and 28 DAT, respectively and reduced plant height by 10% and shoot dry weight by 25% compared to the untreated control. Imazethapyr caused as much as 0, 1, and 17% visual injury, at 7, 14, and 28 DAT, respectively. Crop injury was persistent over time and resulted in a decrease of up to 24, 42, and 24% in plant height, shoot dry weight, and yield of otebo beans, respectively.

Based on these results, dimethenamid and S-metolachlor applied PRE have potential for weed management in otebo beans. Additional research is needed to determine if there is an adequate margin of crop safety in otebo beans to the PRE application of clomazone. However, there is not an adequate margin of crop safety for imazethapyr at the rates evaluated in otebo bean production in Ontario.

EFFECT OF COHORT EMERGENCE ON SOYBEAN YIELD. Thomas J. Ross and Christy L. Sprague, Undergraduate Student and Assistant Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Research was conducted at East Lansing, MI in 2004 to examine the interference potential of a multi-species weed community that emerged at soybean growth stages VE, VC, V1 and V3. Plots were planted with glyphosate-resistant soybean (Asgrow 2107) at 494 000 seeds ha^{-1} in 19-cm rows spacing in a conventionally tilled field. Treatments included plots that were weed-free and four cohort emergence timings that were kept weed-free until soybean growth stages VE (untreated), VC, V1, and V3 with glyphosate applications. The glyphosate rate was 0.84 kg a.e./ha for all applications. Quadrats were established in each plot two weeks after final glyphosate application. At peak weed biomass, weed density, height, biomass, and seed production were recorded. Weeds emerging with the crop produced a biomass of 461 g m^{-2} and reduced soybean yield by 58%. Wild mustard, giant foxtail, common ragweed, and eastern black nightshade were the main species competing with the crop in cohort 1. Weeds emerging at the soybean VC stage produced a biomass of 93 g m^{-2} and reduced soybean yield by 14%. Giant foxtail and eastern black nightshade were the main weeds competing with the crop in cohort 2. Weeds emerging at the soybean V1 stage produced a biomass of 21 g m^{-2} and reduced soybean yield by 11%. Pennsylvania smartweed was the main weed competing with the crop in cohort 3. Weeds that emerged with cohort 4, V3 soybean, did not survive throughout the season to produce biomass and did not significantly reduce soybean yield compared with the weed-free control. Therefore, weeds that emerged at or after V3 soybean were not competitive with the crop in 19-cm rows.

CHLORIMURON ETHYL PLUS TRIBENURON METHYL: A NEW HERBICIDE FOR WEED CONTROL IN SOYBEANS. Kevin L. Hahn, Marsha J. Martin, Susan K. Rick, and David W. Saunders. DuPont Ag and Nutrition, Johnston, IA 50131.

Chlorimuron ethyl plus tribenuron methyl (Canopy® EX) a new fall-applied and early-spring applied herbicide for soybeans received federal registration on October 21, 2004. Prior to the registration of Canopy® EX, chlorimuron ethyl + sulfentrazone (Canopy® XL) tank mixed with tribenuron methyl (Express®) was widely used as a fall-applied and early spring-applied herbicide for burndown plus residual control of winter annual weeds in commercial soybean production fields.

2003 fall-applied research conducted by Universities and DuPont has shown that the sulfentrazone component in Canopy® XL was adding little to no additional efficacy or spectrum of weed control as compared to fall-applied Canopy EX®.

For 2004 early spring-applied timings, Canopy® EX performed similarly to comparable rates of Canopy® XL + Express® for burndown of emerged winter annual weeds at the time of application. Residual weed control of spring germinating weeds with the early spring application timing was similar between Canopy® EX and Canopy® XL + Express® except with the higher rates of Canopy® XL. Higher rates of Canopy® XL provided slightly better early season residual control of a few species of annual grasses and small seeded broadleaf weeds.

INTERACTION OF APPLICATION FACTORS AND TIME OF DAY ON COMMON WATERHEMP AND PALMER AMARANTH CONTROL WITH GLYPHOSATE. Sean D. Nettleton and Bryan G. Young, Graduate Research Assistant, Associate Professor, Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901.

Variable control of common waterhemp with glyphosate has been observed in commercial applications. Two field research studies were conducted near Ina, Illinois in 2004 to determine the extent of variability in glyphosate efficacy that can be attributed to specific herbicide application parameters.

The first study investigated the interaction of carrier volume and application travel speed with two spray nozzle types. Glyphosate was applied by a factorial arrangement of application parameters that consisted of: nozzle type (XR Teejet and AI Teejet), carrier volume (47, 94, 140 and 187 L/ha), and application travel speed (8, 16, 24, and 32 km/h). No differences were observed for control of common waterhemp for any combination of carrier volume or travel speed with the AI nozzles. However, control of common waterhemp with the XR nozzles was greater at 94 L/ha compared with 47, 140, and 187 L/ha. When glyphosate was applied in 187 L/ha, control of common waterhemp was 8% less with the AI nozzles compared to the XR nozzles.

The second study for glyphosate applications utilized a factorial arrangement with carrier volume (47 and 187 L/ha), application travel speed (8 and 32 km/h), and two nozzle types (XR Teejet and AI Teejet), applied at three different times of day (7:00 am, 1:00 pm, and 7:00 pm). Common waterhemp control at 7:00 am was reduced 13% when glyphosate was applied in 187 L/ha compared with 47 L/ha. There was no difference in control of common waterhemp between carrier volumes when glyphosate applications were made at 1:00 pm. Similar to 7:00 am, control of common waterhemp at 7:00 pm was reduced by 6% when glyphosate was applied in 187 L/ha compared with 47 L/ha. There was also an interaction between application time of day and nozzle type. The AI nozzles provided at least10% less control of common waterhemp than any other nozzle and time of day combination.

The efficacy of glyphosate on Palmer amaranth was similar for all glyphosate application methods tested in each study. Palmer amaranth was generally more sensitive to glyphosate than common waterhemp.

INVESTIGATION OF MULTIPLE HERBICIDE RESISTANCE IN SELECTED INDIANA HORSEWEED POPULATIONS. J. Earl Creech, Vince M. Davis, and William G. Johnson, Graduate Research Assistant, Graduate Research Assistant, and Assistant Professor, Purdue University, West Lafayette, IN 47907.

Resistance to glyphosate is an emerging problem in Indiana horseweed populations. However, little is known about the propensity of glyphosate resistant horseweed to also harbor resistance to other herbicidal modes of action. The objective of this experiment was to screen glyphosate resistant horseweed samples collected in southeast Indiana in 2003 for multiple herbicide resistance. A total of 52 horseweed populations were selected, each representing a different degree of tolerance (low to high) to glyphosate, and were grown in a greenhouse in fall 2004. Treatments were applied to 2 to 4 inch horseweed rosettes and included 2,4-D (1 lb/A), cloransulam-methyl (0.05 lb/A), paraquat (1.5 lb/A), glufosinate (0.84 lb/A), atrazine (2 lb/A), chlorimuron (0.02 lb/A), and mesotrione (0.19 lb/A). At 15 DAT, no visual differences were evident among horseweed populations with respect to tolerance to 2,4-D, glufosinate, atrazine, or mesotrione. Regrowth of paraquat treated horseweed was common in three of the populations (33 to 45% of the plants had resumed growth) while many others had no survivors. The horseweed populations screened also appeared to exhibit variable tolerance to cloransulam-methyl and chlorimuron, with 5 to 9 of the populations showing little or no visual injury at 15 DAT.

DISTRIBUTION OF STALK BORING INSECTS IN GIANT RAGWEED IN INDIANA AND SOUTHERN MICHIGAN. Eric J. Ott, William G. Johnson, Corey K. Gerber, Dana B. Harder, and Christy L. Sprague, Graduate Research Assistant, Assistant Professor of Weed Science, Department of Botany and Plant Pathology Purdue University, West Lafayette, IN 47907-2054, Entomologist, Department of Agronomy Purdue University, West Lafayette, IN 47907-2054, Graduate Research Assistant, Assistant Professor of Weed Science, Department of Crop and Soil Sciences Michigan State University. East Lansing, MI 48824.

Previous research has shown that stalk boring insects have an effect on glyphosate efficacy on large giant ragweed. Previous field surveys of stalk boring insects have only accounted for total numbers of each insect and not their distribution. Four regions in Indiana (Northwest, Northeast, Central, and Southwest) and three regions in Michigan (North Central, Southeast, and Southwest) were selected for a survey. In mid-August, five sites located in soybean fields were chosen randomly within each region. Ten giant ragweed plants were then collected from each site. Data collected for each plant include; plant height, if plant had escaped glyphosate application, if insect tunneling was present, length of tunnel, if a stalk boring insect was found, and if an insect was found, the insect was collected in a vial with isopropyl alcohol for preservation for later identification. Insects were then identified to the family level. Seven different insect families (Cerambycidae, Curculionidae, Languriidae, Noctuidae, Torticidae, Argyresthiidae, and Agromyzidae) from three insect orders (Coleoptera, Lepidoptera, and Diptera) were identified from all of the regions. The most common insect families found in giant ragweed in mid-August were the Curculionidae and Noctuidae. Curculionidae made up a larger proportion of the larvae found in Indiana than in Michigan, whereas Noctuidae made up a larger proportion of the larvae found in Michigan than in Indiana.

INFLUENCE OF STEM-BORING INSECTS ON COMMON LAMBSQUARTER CONTROL WITH GLYPHOSATE. Dana B. Harder, Christy L. Sprague, Karen A. Renner, and Christina D. DiFonzo, Graduate Research Assistant, Assistant Professor, and Professor, Department of Crop and Soil Sciences, Associate Professor, Department of Entomology, Agriculture, and Natural Resources, Michigan State University, East Lansing, MI 48824.

Common lambsquarters control with glyphosate in Michigan has been variable. In 2003, beet petiole borers (*Cosmobaris americana*) were found tunneling throughout the vascular tissue of dissected common lambsquarters plants that survived glyphosate application. In 2004, field studies and sampling efforts were established to: 1) determine when initial insect larval feeding occurs in common lambsquarters, 2) determine the extent and distribution of insect infestation in common lambsquarters that escaped control with glyphosate, and 3) evaluate the effect of glyphosate rate, application timing, and insect larval tunneling on common lambsquarters control. At 922 GDD base temperature 4 C (June 23), an unidentified fly maggot was found inside common lambsquarters and at 1278 GDD (July 23) the first beet petiole borer was detected. The number of common lambsquarters infested increased steadily from 1029 GDD (July 1) to 1594 GDD (August 5) with 90% of plants infested. On May 6 and June 4, two separate field studies were planted with glyphosate-resistant soybean. When common lambsquarters plants were 10, 25, and 46 cm in height, glyphosate was applied at 0, 0.63, 0.84, and 1.68 kg ae ha^{-1}. Common lambsquarters plants were examined for insect tunneling prior to and 28 d after each glyphosate application (DAT). Visual control, plant biomass, and number of plants remaining after application were recorded 28 DAT. In the May 6 planting, there were no insects present prior to the 10 or 25 cm application timings. However, 40% of common lambsquarters plants were infested prior to the 46 cm application timing, resulting in significantly less common lambsquarters control compared with the other two application timings. Common lambsquarters infestation rate ranged from 40 to 70% prior to glyphosate application for the June planting, but common lambsquarters control did not differ for the high and medium glyphosate rates across all application timings. The number of plants remaining 28 DAT correlated to the total number of plants infested for the June planting. In August, sampling was conducted in soybean fields throughout Michigan and northern Indiana where it appeared common lambsquarters escaped control. Over 70% of common lambsquarters plants were infested with either the beet petiole borer or fly maggot in 17 of the 29 counties sampled in Michigan and 4 of the 8 counties in Indiana.

STS®/ROUNDUP READY® STACKED-TRAIT SOYBEAN USES FOR MANAGING WILD BUCKWHEAT AND OTHER GLYPHOSATE TOLERANT WEEDS. James D. Harbour, Mick F. Holm, J. Leslie Lloyd, and David W. Saunders, Field Development, DuPont Agriculture and Nutrition, Johnston, IA 50063.

STS®/Roundup Ready® (STS/RR) soybean varieties contain genetic traits conferring increased tolerance to certain ALS-inhibitor herbicides and tolerance to glyphosate. STS/RR soybeans allow farmers additional choices for weed control management without increased risk for crop response. The study objective was to determine the benefit of adding thifensulfuron and/or chlorimuron-ethyl herbicides to glyphosate for enhanced control of broadleaf weeds that may be difficult to control with glyphosate treatments alone. STS/RR soybean were treated with glyphosate applied at 15 oz ai/a alone, glyphosate tank mixed with thifensulfuron at 0.0625, 0.125, or 0.25 oz ai/a, glyphosate tank mixed with chlorimuron-ethyl at 0.125 or 0.25 oz ai/a, or glyphosate tank mixed with thifensulfuron at 0.25 oz ai/a and chlorimuron-ethyl at 0.25 oz ai/a. Ammonium sulfate, at 2% (v/v), was added to all treatments. Overall weed control and crop safety with mixtures of thifensulfuron and/or chlorimuron-ethyl plus glyphosate was as good or better than applications of glyphosate alone, particularly on wild buckwheat and horseweed.

IMPROVED WEED MANAGEMENT DECISIONS USING CROP-WEED SIMULATION MODEL.
Dwain M. Rule and J. Anita Dille, Graduate Research Assistant, Department of Agronomy, Kansas State University, Manhattan, KS 66506-5501 and Assistant Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506-5501.

An improved understanding of plant competitive interactions for resources of light, water, and nutrients, and their impact on growth, is necessary for predicting crop yield loss and making weed management decisions under different environmental conditions. These plant competitive interactions can be simulated with dynamic ecophysiological crop-weed competition models. The ALMANAC (Agricultural Land Management Alternatives with Numerical Assessment Criteria) model was parameterized to simulate both monoculture corn and corn:shattercane competition for Manhattan, Riley County, Kansas. The plant densities for the simulations were 6.0 plant m^{-2} for monoculture corn and 6.0:5.3 plant m^{-2} for corn:shattercane competition, respectively. A representative county soil was chosen and Manhattan, KS weather data were used. Simulated grain yields were compared with grain yields reported by the National Agricultural Statistical Service (NASS) for 1991 to 2003 and yearly trends were similar. The simulated 13 year mean grain yield was 0.47 Mg ha^{-1} greater than the mean NASS grain yield. Simulated and NASS grain yield were correlated with a coefficient of 0.68. Cumulative frequencies indicated that the model closely simulated corn grain yields less than 6.5 Mg ha^{-1} in 60% of the years studied and overestimated higher yields, when compared to the NASS yield. Simulated shattercane competition of 5.3 plants m^{-2} with corn resulted in a 20% mean yield reduction. Monthly precipitation of May to August appeared to predict potential corn yield, which was correlated to simulated yield reductions with shattercane. Based on these initial simulation studies, the ALMANAC model would be useful to evaluate crop yield potential and crop yield reductions from crop:weed competition to improve weed management decisions under different environmental conditions.

RESPONSE OF SELECTED INDIANA HORSEWEED (*CONYZA CANADENSIS*) POPULATIONS TO GLYPHOSATE RATES. Vince M. Davis*, J. Earl Creech, and William G. Johnson, Graduate Research Assistant, Research Assistant, and Assistant Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907-2054.

The threat of glyphosate-resistant horseweed has been growing in geographical distribution and abundance across agricultural landscapes in many states since it was first reported in 2000. However, little has been reported about the differing levels of tolerance to glyphosate among different horseweed populations. The objective of this experiment was to evaluate the efficacy of glyphosate on horseweed populations collected from southeast Indiana in 2003. 388 horseweed samples were screened for glyphosate tolerance, and 116 demonstrated less than 60% visual control at 21 days after application of 1.72 kg ae/ha glyphosate. Based on this initial screen, 3 susceptible populations and 18 resistant populations were selected for a dose response experiment. The resistant populations selected demonstrated 14 to 53% control following the 2X application. These populations were sprayed with eight rates of 0, 0.22, 0.43, 0.86, 1.72, 3.45, 6.90, and 10.35 kg ae/ha glyphosate. At 15 DAT 100% of the resistant samples survived at the 1X rate while the susceptible populations were clearly deceased. At both the 2X and 4X rates, 55% to 94% of the populations across replications appeared to be surviving while only 11% to 39% of the populations are surviving the 8X rate. No populations survived at the 12X rate.

DIFFERENCE IN HERBICIDE RESPONSE AMONG NIGHTSHADE AND GROUNDCHERRY SPECIES IN MICHIGAN. Vijaikumar Pandian* and Bernard H. Zandstra, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Eastern black nightshade, hairy nightshade and horsenettle are often more troublesome in solanaceous vegetable crops than clammy groundcherry and smooth groundcherry. Greenhouse experiments were conducted in 2003 and 2004 to determine any variation in sensitivity among nightshade and groundcherry species to potential herbicides. Eastern black nightshade has a higher range of tolerance to metribuzin and halosulfuron than hairy nightshade, horsenettle, clammy groundcherry and smooth groundcherry. Hairy nightshade was more susceptible to sulfentrazone among nightshade and groundcherry species whereas clammy groundcherry was more tolerant to sulfentrazone than the nightshades and smooth groundcherry. Horsenettle was more susceptible to sulfosulfuron than other nightshade and groundcherry species. All the nightshades and clammy groundcherry are susceptible to pyridate at a lower dose, whereas smooth groundcherry was more tolerant of pyridate.

FLORAL MORPHOLOGY AND POTENTIAL FOR OUTCROSSING IN TWO EASTERN BLACK NIGHTSHADE BIOTYPES. Dean S. Volenberg, Dean E. Reichers, William F. Simmons, and Patrick J. Tranel, Postdoctoral Research Scientist, Assistant Professor, and Associate Professors, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

In evaluating progeny plants from a biotype of eastern black nightshade (*Solanum ptycanthum* L.) for resistance to acetolactate synthase (ALS) inhibiting herbicides, it was determined that some plants were heterozygous for resistance. This suggested that this biotype may outcross even though eastern black nightshade is considered to be a self pollinating species. *Solanum* is a genetically and phenologically diverse genus. There are several examples of different populations of a single species having divergent mating systems, from outbreeding to inbreeding systems. In some instances, these divergent mating systems have been correlated with floral morphology. Therefore, we examined two biotypes of eastern black nightshade for differences in floral morphology. The biotypes originated from central Illinois (IL) and southern Indiana (IN) and both biotypes are resistant to ALS-inhibiting herbicides due to an ALS mutation. Additionally, the biotypes have different fruit colors, with the IL and IN biotype having purple and green fruits, respectively. Five characteristics were examined in relation to floral morphology: anther, filament, and pistil (combined length of style and stigma measured from the junction of the style and ovary) length; style angle; and pistil exertion beyond the anthers (combined length of style and stigma measured from the terminal tip of the anthers). Additionally, anther dehiscence was quantified over time. Twenty flowers from five separate greenhouse-grown plants of each biotype were examined. Measurements were performed with the aid of a dissecting microscope, equipped with a digital imaging camera and computer software that allows measurement of digital images. Preliminary measurements of floral characteristics from ALS-resistant or -sensitive plants showed no differences and so measurements were combined between ALS-resistant and-sensitive plants within each biotype. The two biotypes differed in four floral characteristics. The IN biotype had a longer pistil and the pistil exerted beyond the anthers farther, compared to the IL biotype. Additionally, the style angle of the IN biotype was greater compared to the IL biotype. Only the anther length was greater in the IL biotype compared to the IN biotype. The literature has reported that anther dehiscence in eastern black nightshade occurs immediately after the flower opens. This was observed in the IL biotype; however, anther dehiscence in some flowers of the IN biotype had not occurred after 7.5 hours of flowering. Additionally, the IN biotype produced flower buds in which the pistil protruded through the petals, and the stigma was receptive at this time. These physical and temporal separations of male and female function in the IN biotype may predispose it to higher rates of outcrossing compared to the IL biotype. A field study is currently addressing whether this is the case.

SOLARIA PROVIDE PREPLANT INFORMATION ON WEED DENSITIES, DISTRIBUTIONS, AND MANAGEMENT. Juan J. Eyherabide, Dean Peterson, and Frank Forcella, Professor, Universidad de Mar del Plata, Balcarce, Argentina, and Agricultural Science Technician and Research Agronomist, USDA-Agricultural Research Service, Morris, MN 56267.

Solaria are transparent plastic films that are used to cover the soil surface in early spring to stimulate precocious emergence of weeds. The densities and distributions of these precociously emerged weeds can be used in bio-economic models to aid decisions on weed control well before normal planting times. Sixteen 1-m^2 solaria were placed randomly in a small field in April of 2003 in west central Minnesota. The locations of all solaria were geo-referenced. Prior to planting glyphosate-tolerant (GT) soybean, emerged weeds were identified and counted within each solarium, as well as in adjacent naturally exposed soils. The species and density information, which presumably represented potential in-crop weed infestations, were used in two bio-economic models, WeedSoft and GWM, to generate management recommendations. Two top recommendations from each model were implemented (treatments 1-4). These treatments were expected to provide good weed control and generate high net economic returns. Additionally, there were five other treatments: 5) a standard treatment that might be chosen by local farmers in the absence of GT soybean, 6) a researcher chosen treatment that integrated expected weed control, cost and anticipated net return in the absence of GT soybean, 7) a treatment that purposefully resulted in poor weed control (i.e., a poor management decision, but within the realm of reason), 8) a treatment that might result in excellent weed control, but would be costly and possibly lower economic returns, and 9) a weedy check.

Abundant and easily identified seedlings of several weed species had emerged under solaria by the time of soybean planting in May, which preceded appreciable weed emergence in adjacent ambient soils. Costs of chemical weed control ranged across treatments from $41 to $108 per hectare. Four treatments had net returns > $400/ha. These treatments were: (1) Glyphosate + AMS post, which was recommended by both WeedSoft and GWM, and represented what typical soybean growers use nowadays. A single but timely application provided adequate control of all weed species. (2) Imazamox + UAN + COC post, which was recommended by WeedSoft. It provided adequate weed control, but some common lambsquarters escaped. (6) Flumetsulam pre, which was chosen by the researchers. As expected, it did not control green and yellow foxtail very well, but it did provide adequate control of all other weed species, and it was inexpensive. (8) Quizalofop + COC post followed by imaxamox + UAN + COC post. Some common lambsquarters escaped this treatment, but other species were controlled well. The greater cost of this treatment was compensated by high soybean yields. The second treatment recommended by GWM was flumioxazin pre followed by glyphosate + AMS post. This was an expensive treatment, it did not control wild proso millet and, consequently, its net return was below $400/ha. We concluded the following: First, precociously emerged seedlings under solaria provide sufficiently early and detailed information to make reasonable pre and post weed management decisions. Second, bio-economic models, like WeedSoft, when initialized by solaria-derived data can aid the decision-making process by generating information not only on net returns for the current year but also on the likely abundance of weed escapes that affect management in future years.

TRADEOFF BETWEEN FERTILITY AND GENE INTROGRESSION IN THE BC_1 GENERATION OF WATERHEMP X SMOOTH PIGWEED HYBRIDS. Federico Trucco, Tatiana Tatum, A. Lane Rayburn, and Patrick J. Tranel, Graduate Research Assistant, Graduate Research Assistant, Associate Professor, and Associate Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Numerous recent studies have resurfaced the importance of interspecies hybridization as an evolutionary force. In the realm of weed science, such studies have addressed the likelihood of monogenic herbicide resistance transfer. In particular, field studies have established high potential for hybridization between two important and often coexisting weedy amaranths, waterhemp and smooth pigweed. In essence, pre-mating reproductive barriers between these species are believed to be limited to pollen competition and availability. Moreover, a greenhouse study showed that a herbicide resistance gene (*ALS*) from smooth pigweed could be introgressed into an advanced waterhemp background (BC_2). However, evidence is lacking in support of such transfer in nature. Post-zygotic reproductive barriers may minimize, if not preclude, natural introgression. Indeed, waterhemp x smooth pigweed hybrids are characterized by reduced fertility and even floral neuterism. The purpose of this study was to assess hybrid sterility by profiling BC_1 populations, with specific emphasis on *ALS* introgression. In essence, progeny obtained from backcrossing F_1 females with pollen from waterhemp or smooth pigweed were profiled for genomic constitution, fertility and *ALS* identity. Genomic constitution was inferred from nuclear DNA content and ploidy analyses. Fertility was assessed by measuring seed output and by pollen evaluation. Finally, introgression of *ALS* was determined via a molecular marker system. The obtained data showed that most progeny were homoploid ($2\underline{n} = 32$) and, thus, observed nuclear DNA content (2C) variation could not be explained by aneuploidy. In fact, given the reported difference in the average size of smooth pigweed and waterhemp chromosomes, 2C variation could be explained in the context of random chromosomal assortment into haploid gametes ($\underline{n}=16$). With regard to the genetics of hybrid sterility, fertility indicators (seed production and percent abnormal-size pollen, i.e. micropollen) showed segregation inconsistent with that expected of a single-locus model. Also, lack of correlation between genome reconstitution (as indicated by 2C values) and fertility measurements did not support Fisher's infinitesimal model for post-mating reproductive isolation. The data obtained can be explained best by a system where rather few (but not just one) loci are responsible for fertility penalties. Approximately 3% of the progeny obtained reconstituted parental fecundity. Introgression at *ALS* was negatively correlated with fertility as indicated by seed output ($P = 0.05$) or percent micropollen ($P = 0.03$). Briefly, heterozygotes produced 39% of the seed output and 52% more micropollen than their homozygote siblings. Furthermore, the waterhemp *ALS* allele was not identified in any of the 29 monoecious progeny evaluated. Finally, lack of correlation between dry mass accumulation and *ALS* identity suggests that fecundity penalty in *ALS* introgression is not due to heterozygosity at *ALS* itself. Rather, linkage of *ALS* to a locus associated (directly or via epistasis) with hybrid sterility may explain the fertility penalty related with *ALS* introgression. Moreover, this linkage might explain why sequenced herbicide-resistance *ALS* alleles from smooth pigweed and nearby waterhemp populations show independent evolution.

COMPARATIVE BIOLOGY OF GLYPHOSATE-RESISTANT AND GLYPHOSATE-SUSCEPTIBLE COMMON RAGWEED. Brent A. Sellers, Justin M. Pollard, and Reid J. Smeda, Post-Doctoral Fellow, Graduate Research Assistant, and Associate Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211.

A population (JRW) of common ragweed was confirmed resistant to glyphosate and the I_{50} value was approximately 10-fold greater than the glyphosate-susceptible population (BRAD). Under field and greenhouse conditions, the JRW population appeared to grow slower than the BRAD population, with JRW plants exhibiting shortened internodes, reduced stature and an overall ‘bushy’ appearance. Plants with differing morphology may intercept spray particles differently, thus impacting plant response to postemergence herbicides. An experiment was established to compare growth parameters of JRW and BRAD common ragweed populations, and to determine if these potential differences impact spray interception. Seeds of both populations were planted in pots under natural conditions 1 June 2004. All pots were thinned to one ragweed plant at the cotyledon growth stage (time zero). Destructive harvests were performed weekly for six weeks beginning two weeks after cotyledon expansion. At each harvest time, plant height, node and branch number were recorded; plants were then treated with 2 M KNO_3 to measure spray interception. After spraying, KNO_3 was rinsed from plant tissues and nitrate levels were measure spectrophotometrically. Leaves were then separated from stems and leaf area was measured. Leaf, stem and root dry weights were also recorded. The experiment was conducted as a completely randomized design with 7 replications. At each harvest time, three additional plants were treated with 0.84 kg ae/ha glyphosate (Roundup WeatherMax™). Plant dry weights were recorded four weeks after glyphosate treatment. The JRW population was 1.6- to 2-fold shorter than the BRAD biotype at all harvest times, but stem weight was similar between the two biotypes until five weeks after cotyledon expansion. Node number was 1.2-fold higher for the BRAD biotype versus the JRW biotype at two, three and four weeks, but was similar among the two biotypes at five and six weeks after cotyledon expansion. Except at four weeks after cotyledon expansion, leaf area and leaf dry weight were not different at any harvest time. Although the JRW biotype grows differently than the BRAD biotype, net assimilation rate and relative growth rate did not differ throughout the experiment. Though leaf area was similar among the two biotypes, the BRAD biotype intercepted 1.9-fold more spray than the JRW biotype two weeks after cotyledon expansion. At three and four weeks after cotyledon expansion, spray interception was similar among the two biotypes, but the BRAD biotype intercepted 1.5-fold more spray at five and six weeks after cotyledon expansion. The BRAD biotype was controlled (based on dry weight accumulation) with glyphosate at two, three and four, but not at five and six weeks after cotyledon expansion. The JRW biotype was not controlled at any harvest interval, but control was greatest (24% of the untreated control dry weight) at three weeks after cotyledon expansion. Variability in plant morphology contributes to differences in interception, but this does not fully account for the reduction in glyphosate activity in the JRW population.

THE EFFECT OF INTERPLANT VARIATION ON AMBROSIA TRIFIDA L. EMERGENCE PATTERNS. Brian J. Schutte, Emilie E. Regnier, and S. Kent Harrison, Graduate Research Associate, Associate Professor and Professor, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210

Giant ragweed is a severe annual broadleaf weed in summer annual crop production. The severity of giant ragweed interference in Ohio crop production is partially attributed to prolonged, continuous seedling emergence. Within a population, nonsynchronous emergence can result from interplant and intraplant variation. Giant ragweed populations exhibit a high degree of variation in sizes of diaspores (dispersal units) among individual plants and diaspore size is known to affect emergence phenology of other species. Therefore, we hypothesized that within giant ragweed populations, there is interplant variation in emergence phenology, and diaspore size influences emergence phenology. Diaspores from 25 giant ragweed individuals (i.e. 25 half-sib families) were planted at a uniform depth in the autumn of 2002. In spring of 2003, emergence was monitored on a regular basis. Diaspore dimensions were determined with image analysis software and relationships between diaspore dimensions and emergence were examined. Emergence phenology differed significantly among half-sib families, and two forms of emergence phenology were identified: 1) synchronous and 2) continuous. A negative relationship between dispersal unit dimensions and days to 95% emergence was detected in one population. Definitive conclusions concerning diaspore size and emergence phenology require additional experiments. Results of this experiment show unique emergence behaviors among half-sib families, which could contribute to the overall continuous emergence pattern commonly observed in giant ragweed populations of Ohio crop fields.

PURPLE DEADNETTLE EFFECTS ON SOYBEAN CYST NEMATODE POPULATIONS IN NO-TILL SOYBEAN. R. Venkatesh, S. K. Harrison, E. E. Regnier, and R. M. Riedel, Research Associate, Professor and Associate Professor, Department of Horticulture and Crop Science, and Professor Emeritus, Department of Plant Pathology, The Ohio State University, Columbus, OH 43210.

Purple deadnettle is a common winter annual weed of no-tillage crop fields and serves as alternate host of soybean cyst nematode (SCN). The objectives of our study were to determine (a) the effect of purple deadnettle establishment dates and (b) the effect of purple deadnettle removal times on SCN reproduction in continuous no-tillage soybean. Field studies were conducted in micro plots from 2001 to 2003. A previously non-infested field was inoculated uniformly with SCN in 2001. An SCN-susceptible soybean variety was planted each spring, and purple deadnettle was seeded each fall following soybean harvest. The treatments for establishment date study included a plant-free control, a soybean-only control, and seven purple deadnettle seeding dates ranging from 8/30 to 10/11. Treatments were arranged in a completely randomized design with 7 replications and individual plot size was 2 x 2 m. In the removal time study, purple deadnettle was seeded in all plots on September 7, and treatments consisted of plant-free and soybean only controls, plus seven purple deadnettle removal dates ranging from 5 weeks after emergence (WAE) in the fall to full maturity the following spring (32 WAE). Treatments were arranged in a randomized complete block design with 6 replications and individual plot size was 1 x 2 m. Soil samples were collected from each plot in spring and fall to determine SCN egg population densities in soil.

In September 2002 following the first complete weed and crop cycle, mean SCN egg populations in plots seeded previously with susceptible soybean and purple deadnettle ranged from 380 to 1590 eggs/200 cc soil, compared to 210 eggs/200 cc soil in plots seeded with soybean only. After the second cycle, SCN egg populations in September 2003 showed little change overall from the previous year but were generally higher in plots that had been seeded with purple deadnettle and soybean (540 to 1770 eggs/200 cc soil) compared to soybean alone (340 eggs/200 cc soil). Results of the purple deadnettle removal study showed no differences in SCN egg populations due to removal times in the first year. Second-year results indicated that SCN egg populations were reduced significantly when purple deadnettle was removed in May compared to earlier removal dates in September and October.

The overall results of this study verified that purple deadnettle could contribute to increases in SCN populations under field conditions. Results also suggest that timing of purple deadnettle control may have the potential to reduce SCN egg populations in soil by serving as a trap crop, although more basic information is needed on the temperature dependence and temporal nature of the SCN-purple deadnettle interaction.

VELVETLEAF EPSPS MRNA EXPRESSION WITH TIME OF DAY, GLYPHOSATE APPLICATION, AND LEAF NUMBER. Aaron L. Waltz, Don J. Lee, Alex R. Martin, and Fred W. Roeth, and Scott R. Baerson, Graduate Student, Professor, Professor, Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE 68583-0915, and Research Scientist, USDA-ARS Natural Products Research Unit, University, MS 38655.

Much is known about commercialized glyphosate-resistant EPSPS expression, but very little information exists about native EPSPS expression. What are the expression levels or patterns of the EPSPS enzymes from important weed species? Does mRNA expression data give any information as to the susceptibility of weed species to glyphosate or changes in expression with growth stage, time of day, or in response to glyphosate application?

EPSPS mRNA expression was studied using real-time PCR. Degenerate EPSPS primers were designed using consensus sequence from available databases. The species involved was velvetleaf. Plants were placed in a growth chamber (25 +/- 2 C night/day, 60-70% RH, 15 hr photoperiod from 6:00 to 21:00) one week before treatments were applied. For time of day experiments, leaves were extracted at 5:00, 7:00, 13:30, 20:00, and 22:00. For glyphosate application experiments, plants were sprayed with 1 lb ai/A glyphosate at 13:30. Untreated leaves were extracted at 13:30, while treated and untreated leaves were extracted at 14:15, 15:00, 16:30, 19:30, and 1:30 and 13:30 the following day. Leaf number experiments consisted of extracting leaves 6 through 9 from the same plant. Total RNA was isolated from frozen leaf samples using a modified Trizol method. All experiments for velvetleaf were conducted twice. Initial results indicate changes in EPSPS mRNA expression.

RAPD ANALYSIS ON GENETIC DIVERSITY OF NIGHTSHADE SPECIES IN THE NORTH CENTRAL REGION. Altanbadralt Sharkhuu, Peter B. Goldsbrough, Stephen B. Goodwin and Stephen C. Weller, Departments of Horticulture, and Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Research was conducted to study the genetic diversity of eastern black nightshade species sampled in the North Central (NC) U.S. (Michigan, Indiana, Illinois and Ohio) using Random Amplification of Polymorphic DNA (RAPD) analysis. These species were compared to solanaceous species from the NC and other areas of the U.S. including the annual nightshades horsenettle, American black nightshade and bitter nightshade, and perennials clammy groundcherry and smooth groundcherry. Twenty-five accessions of eastern black nightshade collected from various sites in the NC region were studied. In the initial RAPD analysis, 38 reproducible bands were compared using polymorphisms produced by eight primers. Data were analyzed using the Numerical Taxonomy and Multivariate Analysis System program (NTSYS-pc). This group of eastern black nightshade plants was divided into 11 subgroups by cluster analysis based on the unweighted pair group method with an arithmetic average (UPGMA). A single accession from each subgroup was selected randomly for further RAPD marker analysis with other solanaceous accessions collected from throughout the U.S. In total, 232 RAPD markers were scored for presence or absence of strong reproducible bands for the sample populations and analyzed with NTSYS-pc. A phenetic tree was constructed based on the scored genetic polymorphisms, and subjected to bootstrap analysis. All accessions within a species had a similarity coefficient >0.75. The genetic relationships developed indicated that eastern black nightshade, black nightshade and American black nightshade species were more genetically similar to each other than to other solanaceous species while bitter nightshade and ground cherry species were distinct. Among the eastern black nightshade accessions studied, all but three were in the same cluster. Accessions of black nightshade, American black nightshade, horsenettle, hairy nightshade and bitter nightshade species were each separated into distinct clusters except for two accessions that were originally considered to be black nightshade and horsenettle species but through RAPD analysis were identified as American black nightshade and eastern black nightshade species. These results confirm that RAPD analysis of genetic polymorphisms is a useful technique to characterize weedy solanaceous species.

SUCCESS OF LANCELEAF SAGE (*Salvia reflexa* Hornem) COHORTS IN SOYBEAN. Gauri A. Nazre and George O. Kegode, Graduate Research Assistant and Assistant Professor, North Dakota State University, Fargo, ND 58105

Lanceleaf sage is an annual broadleaf weed native to North America. Lanceleaf sage has become a problem in recent years in North Dakota. Soybean (*Glycine max*) is a major crop in North Dakota and lanceleaf sage is known to be competitive in soybean. Field studies were conducted to evaluate the influence of lanceleaf sage emergence time relative to soybean emergence on lanceleaf sage biomass accumulation and seed production. Glyphosate resistant soybean was seeded in late May in rows spaced 76 cm apart, and lanceleaf sage was seeded 6 cm from soybean rows 0, 7, 14, 21, 28 and 35 days after soybean seeding. The experiment was arranged as a randomized complete block with six replicates and a plot size of 3.5 m by 2.3 m. Lanceleaf sage emerged 0, 4, 23, 28, 32 and 36 days after soybean emergence. Lanceleaf sage plants were spaced 1 m from each other after thinning and all other weeds were removed by hand or by covering lanceleaf sage plants and overspraying soybean with glyphosate. Lanceleaf sage biomass and seed production was assessed at the time of soybean physiological maturity. Lanceleaf sage that emerged 0 and 4 days after soybean produced 9.4 and 4.6 g of biomass per plant, and 733 and 420 seeds per plant, respectively, but were statistically similar. Lanceleaf sage seedlings that emerged 23 days after soybean or later produced 3.3 g of biomass or less per plant, and 221 seeds or fewer per plant. A linear relationship between lanceleaf sage biomass and seed production (r^2 = 0.68) was observed. This suggests that lanceleaf sage biomass could be used to estimate seed production. Lanceleaf sage competition with soybean was highest when lanceleaf sage emergence was within 4 days of soybean emergence.

GIANT RAGWEED POPULATION DYNAMICS IN GLYPHOSATE-RESISTANT CORN AND SOYBEAN CROPPING SYSTEMS. Mark R. Jeschke and David E. Stoltenberg, Graduate Research Assistant and Professor, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

Weed species with extended emergence periods pose a potential management problem in glyphosate-resistant cropping systems, as this characteristic may allow them to avoid exposure to glyphosate. One such weed species is giant ragweed, which is of particular concern due to its rapid growth rate and high level of competitiveness with crop species. Research was conducted at the University of Wisconsin Arlington Agricultural Research Station from 1998 through 2004 to determine the effects of crop rotation, primary tillage system, and glyphosate-use intensity on weed population dynamics. Six weed management treatments were compared in continuous corn and a corn-soybean annual rotation, across three 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 (POST), glyphosate applied POST and late POST, glyphosate applied POST followed by inter-row cultivation (in corn only), glyphosate applied POST rotated annually with a non-glyphosate herbicide program, a soil-residual herbicide applied pre-emergence followed by glyphosate applied POST, and a non-glyphosate program. The experimental design was a randomized complete block with a split-split block arrangement and three replications. Treatments were maintained in the same location for the duration of the experiment. Plant density of each weed species was counted several times during each growing season and shoot biomass production of each weed species was measured at the end of each season.

Giant ragweed was almost entirely absent from sampled areas in the first year of this experiment. However, within 3-yr, giant ragweed occurred at high densities in the non-glyphosate treatments, and was strongly associated with crop yield losses of up to 87%. This result demonstrated not only the ability of giant ragweed to become established relatively rapidly in corn and soybean, but also to become the dominant species in these crop-weed communities. In subsequent years, giant ragweed occurrence increased in other treatments as well and was associated with substantial crop yield losses. Specifically, giant ragweed densities increased steadily over time in all glyphosate-based treatments. The glyphosate POST/LPOST treatment, which provided an extended period of control for late-emerging giant ragweed relative to other treatments, was the most effective of the glyphosate-based treatments in managing giant ragweed and protecting crop yield. Crop rotation and primary tillage were significant sources of variation in early-season giant ragweed density, with densities typically greater in continuous corn and chisel plow systems. The heterogeneous spatial pattern of giant ragweed populations over 7 yr may have been due in part to a relatively limited seed dispersal range. These results suggest that some glyphosate-based weed management systems are vulnerable to highly-competitive weed species, such as giant ragweed, which can emerge over extended periods of time. However, the extent to which such species proliferate can be affected greatly by other cropping system factors in addition to glyphosate use.

APPLE OF PERU BIOLOGY AND CONTROL IN CORN, SOYBEAN, AND VEGETABLE CROPS. Joel Felix and Douglas J. Doohan, Postdoctoral Research Associate and Associate Professor, Department of Horticulture and Crop Science, The Ohio State University/Ohio Agricultural Research and Development Center, Wooster, OH 44691.

Field, laboratory, and greenhouse research was conducted at the Ohio Agricultural Research and Development Center, Wooster, OH in 2003 and 2004 to study the biology and control of apple of Peru (*Nicandra physalodes* L.) in soybean, corn, and vegetable crops. Apple of Peru is a monotypic, solanaceae summer annual with erect glabrous or sparsely pubescent stems growing up to 2 m tall and reproducing only by seeds. It is also known as *shoofly*, purportedly due to its ability to repel insects. Leaves are broadly ovate, 4-20 cm long and 2-15 cm wide with irregularly toothed margins. The lower leaf surface is glabrous, while the upper surface has pronounced sparse, short, inflated, glandular hairs whose color varies depending on plant pigmentation. Apple of Peru germinates continuously (spring through fall) in agricultural fields if moisture is available. It is an indeterminate plant, with flowering commencing 14 to 25 days after emergence depending on day length. Flowering terminates the apical dominance of the main stem, resulting in branching to form a dense canopy. Apple of Peru has attractive trumpet-shaped purple/lavender flowers that may occasionally be white. Fruits are borne singly in a bladder-like structure encasing a single berry resembling those of their distant cousins, the groundcherries. Unlike groundcherries, however, the berry casing of apple of Peru will rupture on contact at maturity, shattering the seeds. Mature seeds are innately dormant, requiring chemical treatment to alleviate dormancy.

Apple of Peru is a recent invader of fields in north central Ohio. We first identified this weed in several vegetable fields in Seneca and Sandusky Counties in August 2002. In most fields, the distribution was scattered; however, in one 12 ha field, it was found in each of 30 randomly placed quadrats. Apple of Peru has been recorded in Ohio since at least the late 1890's, but was never before observed in farmed land. The weed is conspicuously absent from contemporary weed guides, suggesting it has not been an item of research in the United States.

Laboratory tests to determine seed dormancy were conducted in seed germination chambers, with studies arranged in completely randomized design. Four chemicals were tested for their ability to relieve dormancy: sodium hypochlorite (household bleach), concentrated sulfuric acid (H_2SO_4), 0.2% potassium nitrate (KNO_3) solution as a wetting agent, and gibberellic acid (GA_3). Newly harvested seeds were counted and placed on blue germination paper in a petridish (100 seeds each) wetted either with water, 0.2% KNO_3 solution, or 0.0001 M gibberellic acid (GA_3). Each replication was placed in a zip lock bag to minimize moisture loss and placed in a germination chamber set at 30/25^{o}C for 12/12hr and 8/16hr of light/dark, respectively. Untreated seeds wetted only with water did not germinate, whereas seeds previously soaked in sodium hypochlorite for 2 minutes resulted in 98% germination, with water as a wetting agent. Seeds previously immersed in concentrated sulfuric acid for 2 minutes had 25-45% germination. Using 0.2% KNO_3 as a wetting solution following treatment with sodium hypochlorite resulted in 25-40% germination, and only 25% germination when seeds were emersed in 0.0001M GA_3 for 24 hrs.

Field study results indicated apple of Peru to be a prolific seed producer, capable of producing between 200,000 and 1,200,200 seeds per plant depending on size and growing conditions. Field count data indicated germination of only about 2% of the seeds produced in the preceding season. This suggests the potential for a rapid buildup of a persistent seedbank in the soil. To determine the ability of apple of Peru seeds to germinate from different depths, seeds were placed at 0, 0.6, 1.3, 2.5, 5.0 and 10.0 cm in pots filled with a three-way mix of mineral soil/perlite/peat and placed in a greenhouse room set at 28/15^{o}C (day/night) and a photoperiod of 16/8hrs. Pots were kept moist using a daily fine water mist. Total emergence after 30 days was 60, 77, 80, 60, and 15% for respective seeding depths.

It took longer for seeds placed on the surface to germinate, a fact that may explain why we have not spotted the weed in no-till fields.

A 2-year field study involving apple of Peru at an average density of 3585 seeds ha^{1} timed to germinate at the same time with drilled soybeans resulted in a soybean yield reduction of 568 kg/ha.

Even though greenhouse tests had originally suggested differential tolerance to glyphosate, a field study in 2004 indicated effective control of apple of Peru in glyphosate-tolerant soybeans. Apple of Peru has exhibited sensitivity to triazines, PPO inhibitors, and Mesotrione. But ALS inhibitors such as Imazethapyr, and Rimsulfuron as well as chloroacetamides such as *s*-Metolachlor, Alachlor, and Dimethenamid, exhibit poor to moderate control. The weed is also tolerant of bleaching herbicides such as clomazone. Poor control from Clomazone and *s*-Metolachlor is especially troubling considering their utility in major vegetable production operations.

Initial findings suggest a serious threat if the current apple of Peru infestation is left unchecked, due to many factors. Apple of Peru has shown tolerance to many commonly used herbicides, and it is very competitive with crops. The ability of apple of Peru to produce dormant seeds in large quantities suggests a potential to build up a long lasting seedbank.

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INTERATIONS BETWEEN MESOTRIONE AND SULFONYLUREA HERBICIDES. Christopher L. Schuster, Kassim Al-Khatib, and J. Anita Dille, Graduate Research Assistant, Professor, and Assistant Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66502.

Mesotrione is an effective broadleaf herbicide, but may not control a broad spectrum of grass weeds. As a result, atrazine and/or sulfonylurea herbicides are often mixed with mesotrione for additional grass control. Recent complaints, however, contend that green foxtail and shattercane control is reduced when mesotrione is applied in combination with sulfonylurea herbicides. Greenhouse and field experiments were conducted to evaluate interactions between mesotrione or mesotrione + atrazine and sulfonylurea herbicides when applied to green foxtail and shattercane. In the greenhouse, grass seedlings were treated with the label use rate of mesotrione (105 g ha^{-1}), mesotrione + atrazine (105 + 757 g ha^{-1}), foramsulfuron (37 g ha^{-1}), nicosulfuron (35 g ha^{-1}), or a combination of mesotrione or mesotrione + atrazine with foramsulfuron or nicosulfuron. Visual ratings of plant injury were determined 21 days after treatment (DAT) based on a scale of 0 to 100%. In a separate field study, green foxtail and shattercane seedlings were treated with mesotrione (52.5 or 105 g ha^{-1}), mesotrione + atrazine, foramsulfuron, nicosulfuron, nicosulfuron + rimsulfuron (26 + 13 g ha^{-1}), or a combination of mesotrione or mesotrione + atrazine with foramsulfuron, nicosulfuron, or nicosulfuron + rimsulfuron. Grass injury was visually assessed 21 DAT as described above. In the greenhouse, shattercane had 91 and 93% visual injury following applications of foramsulfuron and nicosulfuron, respectively. The addition of mesotrione to foramsulfuron or nicosulfuron decreased visual injury to 81 and 72%, respectively. Antagonistic interactions were also observed with green foxtail. Furthermore, the addition of mesotrione + atrazine to foramsulfuron or nicosulfuron resulted in antagonistic interactions, which decreased the visual injury of green foxtail and shattercane. Similar antagonistic interactions were observed under field conditions; where the efficacy of foramsulfuron, nicosulfuron, or nicosulfuron + rimsulfuron was reduced by tank mixing with mesotrione or mesotrione + atrazine. Antagonistic effects were less when the reduced rate of mesotrione was applied with the sulfonylurea herbicides. Results from both the greenhouse and field study showed that the addition of sulfonylurea herbicides to a mesotrione application will result in decreased efficacy of sulfonylurea herbicides on green foxtail and shattercane.

WEED CONTROL AND SOIL LONGEVITY OF KIH-485, ACETOCHLOR, DIMETHENAMID, AND S-METOLACHLOR. Chad D. Dyer, Thomas T. Bauman, Michael D. White, Department of Botany and Plant Pathology, Lilly Hall of Life Sciences, 915 W. State Street, Purdue University, West Lafayette, IN 47907-2054.

Two field studies were conducted at the Agronomy Center for Research and Education (ACRE) located in West Lafayette, Indiana. The first field study was conducted on a Chalmers silt loam soil with 3% organic matter, and was setup in a randomized complete block design with four replications. The efficacy of KIH-485 60%WG applied at three rates, .75oz ai/ac, 1.49oz ai/ac and 2.98oz ai/ac was compared to acetochlor applied as Harness 7EC at the rate of 1.75lb ai/ac and S-metolachlor applied as Dual II Magnum at the rate of 1.52lb ai/ac using four weed species, jimsonweed, velvetleaf, ivyleaf morningglory, and shattercane. KIH-485 provided significantly superior control in every specie; and most species were controlled at 90% or higher.

The second field trial was conducted at the ACRE on a Chalmers silt loam soil with 3% organic matter and was setup in a randomized complete block design with four replications. The soil persistence of KIH-485 60%WG, acetochlor applied at Harness 7EC, S-metolachlor applied as Dual II Magnum, and dimethenamid applied as Outlook 6EC was determined 10wks after application using three grass species, barnyardgrass, wild oat and green foxtail. KIH-485 60%WG applied at 2.98oz ai/ac provided 69%, 80% and 95% control of green foxtail, wild oat and barnyardgrass, respectively. Acetochlor applied at 1.75lb ai/ac provided 0%, 3% and 46% control of green foxtail, wild oat and barnyardgrass, respectively. S-metolachlor applied at 1.52lb ai/ac provided 10%, 0% and 55% control of green foxtail, wild oat and barnyardgrass, respectively. Dimethenamid applied at .94lb ai/ac provided 10%, 8% and 24% control of green foxtail, wild oat and barnyardgrass, respectively.

OPTIMIZING WEED MANAGEMENT IN GLYPHOSATE-RESISTANT CORN (*Zea mays*). Chad L. Smith and Reid J. Smeda, Graduate Research Assistant and Associate Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211

Traditional weed control strategies for corn indicated the use a of PRE and/or POST herbicides. The advent of glyphosate-resistant corn creates options such as strict dependence upon POST herbicides. Ideally, producers prefer a single timing for herbicide application. However, the unpredictability of weather and corn sensitivity to weed competition can necessitate multiple applications. The objective of this study was to determine the efficacy of PRE, PRE + POST, and POST only herbicide programs in glyphosate-resistant corn. Field studies were conducted in 2003 and 2004 in central and northeast Missouri. Treatments included six, one-pass programs and nine, two-pass programs. Glyphosate-resistant corn was planted in 76 cm rows under a conventional tillage system. Weed control was visually evaluated for giant foxtail, common waterhemp, common ragweed, Pennsylvania smartweed, and velvetleaf 5 weeks after the final herbicide application was made. Management programs consisting of sequential applications of glyphosate at 0.84 kg ae/ha or *s*-metolachlor followed by an application of glyphosate at 0.84 kg/ha were the only two-pass treatments which resulted in >90% weed control across all four-site years. A tank mix containing 0.07 kg ai/ha of mesotrione, 1.68 kg ai/ha atrazine, and 0.84 kg/ha of glyphosate applied on 10 cm weeds was the only one-pass system that provided >90% giant foxtail control across all four site-years. In site-years where other species such as common ragweed and Pennsylvania smartweed were present, weed control from all one-pass programs were comparable to control in the two-pass programs. The spectrum of weeds controlled was broadened in treatments that contained atrazine. For 3 of the 4 site-years, grain yield in plots that received a single application of glyphosate were at least 12% lower compared to plots that received sequential glyphosate applications. Grain yield for PRE only, PRE followed by POST, and sequential POST glyphosate applications was comparable in 2 of the 4 site years. Grass weed control was poor following an early post-emergence application of dimethenamid-p + atrazine, and as a result grain yield was up to 32% lower compared to plots receiving sequential glyphosate applications. For 3 of the 4 site-years, plots that received a single application of glyphosate when weeds were 10 - 15 cm in height resulted in grain yields that were decreased by as much 19% when compared to treatments that received sequential applications of glyphosate. Glyphosate only weed management programs in corn can result in comparable weed management and grain yield comparable to traditional weed management programs, but early season weed competition can result in significant reductions in grain yield.

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 relationships for herbicides with soil activity. Little is known about the relative dissipation rates of two recently introduced herbicides: mesotrione and isoxaflutole. Our study had three objectives: 1) to determine if there is a significant difference in the length of control between preemergence (PRE) applications of isoxaflutole and mesotrione 2) to explore the possibility of a soil pH interaction with herbicide degradation rates and 3) to estimate the half-lives with relation to the degradation rates. Greenhouse bioassay experiments were conducted on field-sampled soils treated with isoxaflutole and mesotrione in 2002, 2003 and 2004 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 then mixed and re-planted after successive 15-day grow-out periods until no visible control was observed. This same method was adapted for use in estimating half-lives by using the greenhouse spray chamber to apply ¼X to $^{1}/_{128}$X rates of the two herbicides. Herbicide efficacy based on bioassay results found mesotrione at 211 g ha^{-1} rates consistently outperformed all isoxaflutole rates. Soil-dissipation rates based on decrease of velvetleaf control from 100% to 80% ranged from 7 to 28 days.

RESIDUAL NITRATE LEVELS AS AFFECTED BY SPRING VS FALL ALFALFA CONTROL AND MANURE APPLICATION IN AN ALFALFA-CORN CROPPING SYSTEM. Bradley E. Fronning and Kurt D. Thelen, Graduate Research Assistant and Associate Professor, Department of Crop and Soils Science, Michigan State University, East Lansing, MI. 48824.

It is possible in the near future there will be a swing in crop production practices to more no-till practices and less tillage. Corn crops require large amounts of nitrogen to reach their potential yields. Under no-till practices it can be difficult to get enough nitrogen in the soil for the corn to develop and yield well. This research could help with that problem. If there is a difference among soil nitrogen levels in these treatments it could help producers get more nitrogen in the soil naturally without the use of artifical fertilizers. An added benefit of it would be that by using the no-till production practices it is possible that the producers could be sequestering carbon and helping reduce the emission of greenhouse gases.

Studies were conducted at Michigan State University near East Lansing and at Kellogg Biological Station near Hickory Corners, Michigan to determine the effect of spring vs fall control of alfalfa and manure application on soil nitrate levels available to the following corn crop. There were seven treatments: fall applied glyphosate + 2,4-D + fall manure, fall applied glyphosate + 2,4-D, spring applied glyphosate + 2,4-D + fall manure, spring applied glyphosate + 2,4-D, glyphosate applied 24 hours prior to corn planting (EARLY), glyphosate applied 24 hours prior to planting (LATE), and an untreated alfalfa check. Plots were 6 by 12.2 m and replicated 4 times at each location. This study was conducted over two years. Soil nitrate-nitrogen was measured to a depth of 0.9 m. Soil cores were collected twice a year, once in the fall and once in the spring.

Alfalfa control ranged from 83% with the LATE glyphosate treatment to 97% with the spring glyphosate +2,4-D treatment on May 9, 2003. On July 9, 2003 all treatments except the untreated provided greater than 90% control of alfalfa. There were significant differences among treatments in soil nitrate nitrogen in the spring of 2003 at the East Lansing site. Yield was significantly affected by treatment.

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

Field pansy (*Viola rafinesquii*) is becoming a problematic weed in northeast Kansas no-till fields. It is a winter annual native to North America, that can germinate both in the fall and spring. Previous work has shown poor or erratic weed control from many spring burndown treatments. Field studies were conducted over the past two years in northeast Kansas no-till fields, to evaluate various herbicide tank-mix combinations at two application timings (fall and spring), on field pansy control ahead of either corn or soybeans. Ahead of corn, year was significant, so data is presented separately. Additionally, we were unable to get the 2003 fall-applied treatments out ahead of corn due to trouble finding a satisfactory site, so only fall applied data from 2002 is represented. Ahead of corn in 2002, 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%. In 2003, an overall decrease in control was observed from the spring-applied treatments compared to 2002, with control ranging from 60% to 100%. Ahead of soybeans there was no year interaction so data was combined. Most of the fall-applied treatments provided good control ranging from 80% to 100%, with similar results obtained from the burndown-only treatments and residual treatments. In the spring-applied treatments, control ranged from 50% 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.

LEXAR: A NEW MESOTRIONE, S-METOLACHLOR, AND ATRAZINE PREMIX FOR THE CENTRAL AND SOUTHERN CORN BELT. Dain E. Bruns, Charles F. Grymes, and Michael D. Johnson, Research and Development Scientist, Research and Development Scientist, and Technical Brand Manager, Syngenta Crop Protection, Inc., Greensboro, NC 27419.

Lexar™ 3.7 SC herbicide is a pre-package mixture of mesotrione with *S*-metholachlor and atrazine from Syngenta Crop Protection, Inc. This new mixture was developed for preplant, preemergence, and early postemergence use in corn. Lexar herbicide applied prior to weed emergence provides excellent control of most important broadleaf and grass weeds in corn including velvetleaf, pigweed species, waterhemp species, common lambsquarters, common ragweed, jimsonweed, nightshade species, Pennsylvania smartweed, foxtail species, barnyardgrass, fall panicum, broadleaf signalgrass, and crabgrass. Corn shows excellent tolerance to Lexar herbicide.

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 C. 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, Ottawa, and Tribune, KS in 2003 and 2004 to evaluate two prepackaged mixtures, mesotrione&S-metolachlor (1:10 ratio) and mesotrione&S-metolachlor&atrazine (1:10:3.7 ratio) 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. Application rates were mesotrione&S-metolachlor at 2.06 kg/ha, mesotrione&S-metolachlor&atrazine at 2.76 kg/ha, S-metolachlor&atrazine (1.247:1 ratio) at 2.52 kg/ha or (0.774:1 ratio) at 3.24 kg/ha. In 2003, only slight sorghum injury (8% or less) was observed at two locations while no injury was observed at the other three locations. Grain sorghum yields were similar among treatments at three of the five locations while yields were highest with PRE treatments applied at 2X rates at Tribune and Hays. In 2004, no sorghum injury was observed at Hays or Ottawa. Mesotrione&S-metolachlor&atrazine at the 2X rate applied PRE injured sorghum 9% at Tribune. All herbicide treatments injured sorghum at Manhattan enhanced by 12 inches of precipitation following sorghum planting and herbicide applications, however, yields were not different among herbicide treatments or timings. All herbicides treatments at the 2X rate applied PRE injured grain sorghum 11 to 19% and treatments containing mesotrione at the 2X rate reduced grain sorghum yields 8 to 9% at Hesston. Grain sorghum yields were not different among treatments at Ottawa. Averaged over herbicide treatments, grain sorghum yields were 10% lower with PRE than 10 or 20 DBP timings at Hays.

All treatments at one or more locations during 2003 and 2004 controlled green foxtail, large crabgrass, carpetweed, redroot pigweed, Palmer amaranth, tumble pigweed, kochia, and Russian thistle. Puncturevine and common cocklebur were controlled 80% or better with all treatments.

These results indicate that grain sorghum has adequate tolerance to soil applied mesotrione&S-metolachlor and mesotrione&S-metolachlor&atrazine at the 1X rate and that these herbicides could offer effective weed control in grain sorghum. Sorghum injury is possible under certain conditions, however, injury and yield reductions observed from mesotrione mixtures are acceptable compared to yield reductions from heavy weed infestations. At this time, these herbicides are not registered for use in grain sorghum.

Weed Management Survey of Indiana Corn and Soybean Producers. David Hillger, Kevin Gibson and William Johnson, Purdue Univ., West Lafayette, IN

Corn and soybean farmers across Indiana were surveyed in 2003 to determine the perceived importance of weeds at the state and district levels. Weeds were considered the primary crop pest by 69% to 84% of farmers, depending on district. Disease and insects were ranked first by no more than 14% of farmers and nematodes were ranked first by no more than 11%. Giant ragweed, Canada thistle, common lambsquarters, common cocklebur, and velvetleaf were considered the most problematic summer annual and perennial weeds statewide. Chickweed, horseweed, dandelion and henbit were considered the most problematic winter annual weeds statewide. However, no weed species was listed by more than 41% of farmers statewide suggesting that relatively unique weed management problems may exist on many farms. Also, the perceived importance of most weed species varied substantially among Indiana's nine districts. For example, velvetleaf was not listed as a problematic weed by any farmers in three districts. Burcucumber was not considered a statewide problem but was listed among the top three weeds by 14 and 16% of farmers in two southern districts. This survey supports the idea that educational programs focused on weed management should be tailored to geographic regions within Indiana.

TWO YEARS RESULTS WITH KIH-485: A NEW, BROAD-SPECTRUM HERBICIDE. Peter J. Porpiglia, Kumiai America, White Plains, NY; Masao Nakatani, K-I Research Institute, Fukude, Japan; and Ryohei Ueno and Yoshihiro Yamaji, Kumiai Chemical Industry Co., Ltd., Tokyo, Japan.

KIH-485 is a new, preemergence herbicide from Kumiai Chemical Industry Co. Ltd. for use in corn and other crops. The objectives of wide-scale field-testing in 2003 and 2004 throughout the US corn-belt were (1) to confirm the spectrum of activity at targeted use rates in various soil textures and (2) compare weed control characteristics of KIH-485 to s-metolachlor, acetochlor and other pre-emergent grass herbicides. Field studies confirmed that KIH-485 gives excellent control of important annual grasses in the *Setaria*, *Digitaria*, *Echinochloa*, *Panicum*, and *Sorghum* genera as well as representative broadleaf weeds in the genera *Amaranthus*, *Datura*, *Solanum*, *Abutilon*, *Chenopodium* and others. KIH-485 also generally provided better activity on difficult to control grasses such as *P. miliaceum*, *P. texanum*, and *S. bicolor* than current commercial pre-emergent herbicides. At target rates, mixtures with atrazine or other herbicides offered little additional control of grasses over KIH-485 alone, but did provide some benefit for control of certain broadleaf species on heavier soils. KIH-485 provided good residual activity and appears well suited to a range of preemergence application timings. Corn tolerance was generally excellent but rate dependent. Mode-of-action and characterization studies of KIH-485 are underway. The chemistry has not yet been released.

COMPARISON OF KIH-485 AND *S*-METOLACHLOR IN CORN. Patrick W. Geier and Phillip W. Stahlman, Assistant Scientist and Professor, Kansas State University Agricultural Research Center, Hays. KS 67601.

Field research conducted near Hays, KS in 2003 and 2004 compared the efficacy and crop response of KIH-485 at four rates (123, 168, 246, or 302 g/ha) with *S*-metolachlor at four rates (1075, 1456, 2130, or 2580 g/ha) preemergence in field corn. Treatments of KIH-485 plus atrazine (134 plus 1340 g/ha), a package mixture of *S*-metolachlor&atrazine (1075&1340 g/ha), and a nontreated control were included both years. All herbicides controlled redroot pigweed 94% or more in 2003, whereas green foxtail was controlled 89 to 100% in both years. KIH-485 provided similar to slightly greater control of puncturevine and common lambsquarters when compared to *S*-metolachlor in 2003. The addition of atrazine to either herbicide improved control of puncturevine but not common lambsquarters. KIH-485 at 123 g/ha controlled Palmer amaranth better than *S*-metolachlor at 1075 g/ha regardless of rating date in 2004; however, atrazine plus KIH-485 or *S*-metolachlor controlled Palmer amaranth best. Longspine sandbur was the most difficult to control weed; 50 to 74%, regardless of treatment. Sandbur control increased as rate increased with either KIH-485 or *S*-metolachlor but did not differ between the two herbicides. Generally, atrazine plus either herbicide was the most efficacious on sandbur.

Corn in all herbicide-treated plots matured 2 to 4 days sooner and was 7 to 15 cm taller at maturity than nontreated corn. Corn maturity and height generally were similar between herbicide treatments. Due to late-season drought and severe weed competition, corn yields were not determined in 2003. In 2004, grain yields were 43 to 81% greater (3980 to 5040 kg/ha) in plots receiving KIH-485 alone compared to nontreated corn (2780 kg/ha). Yields did not differ between nontreated corn and corn in plots receiving *S*-metolachlor at 1075, 1456, or 2580 g/ha, KIH-485 plus atrazine, or *S*-metolachlor&atrazine.

FLUFENACET PLUS ISOXAFLUTOLE (RADIUS) A NEW CORN PREEMRGENCE HERBICIDE FROM BAYER CROPSCIENCE. John R. Hinz, George Simkins, Jim Wolk, Brent Philbrook, John Wollam and Mark Wrucke, Field Development Representative, Technical Service Representative, Field Development Representative, Product Development Manager, Regional Research Manager and Technical Service Regional Manager, Bayer CropScience RTP, NC 27709.

Radius is a new mixture of flufenacet and isoxaflutole for weed control in corn. Radius is a 480 g ai. per liter SC with an 8.33:1 ratio of flufenacet to isoxaflutole. Research was conducted throughout the corn growing regions to evaluate efficacy, phytotoxicity and yield responses to Radius. All experiments were conducted in small plots with 3 replications for phytotoxicity and efficacy evaluations. Yield experiments were conducted under weed-free conditions and contained either 4 or 6 replications. Radius and Camix had similar phytotoxicity responses. Maximum phytotoxicity was 2% and 1% for Radius and Camix. Radius plus atrazine and Lumax had maximum phytotoxicity ratings of 5% and 2%. Giant foxtail, green foxtail, large crabgrass, fall panicum, redroot pigweed common waterhemp, velvetleaf and common lambsquarters were all controlled at least 92% by Radius and Camix. Radius plus atrazine and Lumax both provided at least 94% control of these weeds. On soils with less than 1.5% organic matter or greater than 7.5 pH, there was no difference in phytotoxicity between Radius and Camix. Radius plus atrazine on these same soils was as safe as or safer than Lumax, with only minor injury. No yield differences were detected between the untreated, flufenacet plus atrazine and Radius plus atrazine.

NEW ONE-PASS WEED CONTROL PROGRAMS FOR CORN IN THE NORTHWEST CORNBELT. Brett R. Miller, Adrian J. Moses and Michael D. Johnson, Syngenta Crop Protection, Greensboro, NC 27419.

Lumax™ herbicide from Syngenta Crop Protection has been widely adopted as a one pass pre-emergence herbicide for broad-spectrum weed control in corn. Lumax herbicide provides excellent control of most important broadleaf and grass weeds including velvetleaf, pigweed species, waterhemp species, common lambsquarters, common ragweed, jimsonweed, nightshade species, Pennsylvania smartweed, foxtail species, barnyardgrass, fall panicum, broadleaf signalgrass and crabgrass when used pre-emergence in corn. In the Northwest Corn Belt Lumax tank-mixes with glyphosate and glufosinate applied at an early post-emergence timing are very effective at controlling a broad range of weeds in corn hybrids tolerant to glyphosate or glufosinate. These treatments provide season long control of weeds with less dependence on activating rainfalls. Corn also has excellent tolerance to these new post-emergence herbicide options.

RESPONSE OF BROADLEAF WEEDS TO SELECTED HERBICIDES AND PREPACKAGED HERBICIDE COMBINATIONS IN MISSOURI PASTURE AND HAY FIELDS. Jianmei Li, Kevin W. Bradley, Jimmy D. Wait, and Reid J. Smeda, Research Specialist, Assistant Professor, Research Associate, and Associate Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211.

Three field trials were conducted to evaluate the effect of several herbicides and prepackaged herbicide combinations on broadleaf weed control in pastures near Columbia, Missouri. Key broadleaf weeds that were evaluated in these trials include tall ironweed, Missouri goldenrod, curly dock, and broadleaf plantain. In the first field trial, 0.17 lb ai/a picloram plus 0.17 lb ai/a fluroxypyr provided 86 and 92% visible control of tall ironweed and Missouri goldenrod, respectively. Picloram plus 2, 4-D at 0.135 plus 0.5 lb ai/a also provided similar levels of tall ironweed and Missouri goldenrod control at 60 days after treatment (DAT). Metsulfuron alone at 0.0113 lb ai/a provided excellent control of Missouri goldenrod but essentially no control of tall ironweed 60 DAT. Dicamba plus 2, 4-D at 0.5 plus 1.0 lb/a provided 83% control of Missouri goldenrod and 73% control of tall ironweed. The remainder of the herbicide treatments evaluated, including 1.0 lb/a 2, 4-D, 0.7 lb/a 2, 4-D plus 0.25 lb/a dicamba, and 0.375 lb ai/a triclopyr plus 0.125 lb ai/a fluroxypyr, generally provided less than 75% control of either species 60 DAT. In the second field trial, standard use rates of the prepackaged herbicide combinations clopyralid plus 2, 4-D and picloram plus 2, 4-D provided greater than 80% control of tall ironweed at 65 DAT. However, only the higher rates of the metsulfuron plus dicamba plus 2, 4-D prepackaged combination provided similar levels of tall ironweed control. All herbicide treatments resulted in forage yields that were significantly lower than the untreated control, but there were no differences in forage yield among the herbicide treatments. In the third field trial, standard use rates of the picloram plus 2, 4-D, triclopyr plus fluroxypyr, picloram plus fluroxypyr, clopyralid plus 2, 4-D, and metsulfuron plus 2, 4-D plus dicamba prepackaged combinations provided excellent control of curly dock 60 DAT. Applications of 2, 4-D or dicamba alone provided lower levels of curly dock control. Only dicamba at 1.0 lb/a and triclopyr plus fluroxypyr at 0.375 plus 0.125 lb/a provided less than 80% control of broadleaf plantain 60 DAT.

EVALUATION OF GLYPHOSATE RESISTANT ALFALFA IN A FORAGE PRODUCTION SYSTEM. S. Ann McCordick, James J. Kells, and Richard H. Leep, Graduate Student, Professor, and Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824-1325.

Weed control during alfalfa establishment is a challenge for forage producers. Glyphosate resistant alfalfa provides a new option for weed management during alfalfa establishment. Field studies were initiated in 2003 and 2004 to determine the effect of establishment method and weed control method on forage production, forage quality and alfalfa stand establishment in glyphosate resistant alfalfa. Seeding methods included clear seeding and companion seeding with oats. Herbicide treatments included glyphosate, imazamox (clear seeding) or imazamox + clethodim (companion seeding), and no herbicide. No alfalfa injury was observed from glyphosate. In 2003, seeding method and weed control method did not affect total seasonal forage production. In 2004, total forage yield was reduced where a herbicide was applied, especially in the companion seeding. With no herbicide application, forage yield was higher with the companion seeding compared with the clear seeding. With herbicide application, no differences in forage yield were observed between the establishment methods. Weed control increased total seasonal alfalfa production in both establishment methods in each year. With no herbicide application, alfalfa yield was higher with the clear seeding system. With the conventional herbicide system, alfalfa yield was higher with the companion seeding in 2003, with no differences observed in 2004. With glyphosate, no differences in alfalfa yield were observed between establishment methods in either year. In each year, total seasonal weed biomass was reduced where a herbicide was applied, regardless of establishment method. Alfalfa plant density in the fall of the establishment year was not affected by establishment method or weed control method in either year.

FIELD COMPETITION BETWEEN GIANT CHICKWEED (MYOSOTAN AQUATICUM) AND ALFALFA. Joseph D. Bollman and Michael P. Crotser, Department of Plant and Earth Science, Undergraduate Research Assistant and Assistant Professor of Agronomy, University of Wisconsin at River Falls, River Falls, WI 54022.

A field replacement series study was conducted in River Falls, WI in 2004 to investigate competitive interactions between alfalfa and giant chickweed plants grown at different proportions. The experiment was a randomized complete block design with three replications. Four-leaf giant chickweed transplants were planted on June 18 into direct seeded alfalfa within 1.2 m^{-1} plots. Plots were then thinned to proportions of 0:100, 25:75, 50:50, 75:25, and 100:0 of alfalfa to giant chickweed plants, respectively. Each plot totaled of 100 plants and areas surrounding the plots were kept weed-free by hand removal.

The relative growth and performance of alfalfa and giant chickweed was determined by calculating plant relative yield (PRY); the per plant mass in monoculture divided by the per plant mass in mixed species stands. A PRY value greater than one indicates greater intraspecific vs. interspecific competition, whereas a PRY value less than one indicates greater interspecific vs. intraspecific competition. In addition, the relative per-unit area productivity for a particular proportion of two species can be predicted by calculating the relative yield total (RYT). A RYT greater than one suggest annidation or avoidance of competition (greater biomass productivity per unit area in mixed stands vs. monoculture), while RYT less that one suggest antagonism (less biomass productivity per unit area in mixed stands vs. monoculture).

The study was harvested on July 29 and shoot dry weights were determined and expressed on a per-plant basis. Sub-samples of dry matter were analyzed for forage quality, including ash content, neutral detergent fiber, and crude protein. PRY and RYT were calculated and these data with plant weights, and forage quality values were analyzed using analysis of variance. If means were significantly different, they were separated using Fisher's protected LSD test.

Giant chickweed shoot biomass and PRY were not influenced by the different alfalfa to giant chickweed proportions, suggesting giant chickweed is equally competitive in mixed stands and monoculture. Greatest alfalfa shoot biomass was observed at the 100:0 alfalfa to giant chickweed proportion, while lowest biomass was observed at the 75:25 alfalfa to giant chickweed proportion. Alfalfa PRY was negatively influenced by interspecific competition with giant chickweed. Proportions of 50:50 and 75:25 of alfalfa to giant chickweed noted PRY values significantly lower than 1.0, indicating alfalfa is less competitive in mixed species stands than when grown alone. RYT values for the majority of the mixed species proportions suggested neither greater nor less biomass productivity per-unit area. Giant chickweed present in any of the forage samples significantly increased ash content. Greatest crude protein and lowest neutral detergent fiber levels were observed in pure stands of alfalfa. This data suggests forage quality increases as the proportion of alfalfa increases.

LONG-TERM CANADA THISTLE MANAGEMENT IN PASTURES. Jerry D. Doll. Extension Weed Scientist, Department of Agronomy, University of Wisconsin, 1575 Linden Dr., Madison, WI 53706.

While Canada thistle may be a minor concern in annual cropping systems and forage crops that are in rotation with grain crops, it remains a significant problem in pastures, CRP sites, roadsides and similar areas. Many livestock producers are content to live with Canada thistle as long as their grazing and mowing practices keep it to tolerable levels. While this seems to work for many, Canada thistle can reach levels that reduce the utility and productiveness of pastures and producers in this situation look for herbicides to control Canada thistle. The available alternatives vary in degree of effectiveness and cost (usually inversely related). Research in Wisconsin and elsewhere finds that among the selective herbicides, clopyralid is the most effective molecule to control Canada thistle. It is also the most expensive one.

In 2000, we started a long-term project on Canada thistle in a working pasture at our Agricultural Research Station near Lancaster, Wisconsin to compare various strategies of Canada thistle management with the goal of finding the most economical one for grazed pastures. The trial will last at least five years so that reasonable estimates of the long-term costs and benefits can be made.

The trial has four basic systems as starting points and then we either stay with the same product or shift to a different one when retreatment is needed for a total of 12 treatments. The four systems are clopyralid (0.23 lb ae/a), metsulfuron (5.0 g ai/a), dicamba (1.0 lb ae/a as dicamba) and clopyralid plus dicamba (half rate of either product alone) which were broadcast applied in 2000 to a moderate population of Canada thistle in a pasture routinely grazed by beef cattle at the Research Station. Herbicides were applied in mid June (except for 2002 when the date was July 19) following a grazing event using a CO_2 backpack sprayer fitted with extended range flat fan nozzles. The spray volume was 20 gal/a in 2000 and 2001 and 15 gal/a in 2002-2004. Recommended additives, if any, were used at labeled rates. Plots were 20 by 25 ft and treatments were replicated three times.

The decision to treat or not in 2001 and beyond was based on both Canada thistle population counts and a visual assessment in June. We placed a measuring tape diagonally cross each plot in June and dropped a 2x2-ft quadrat five times along the tape in each plot at set points (5, 10, 15, 20 and 25 ft) and counted and recorded all Canada thistle stems found. A visual assessment of thistle abundance (0 to 100 scale) was also done; this is closer to what the producer would do to determine if herbicides are to be used or not. We generally used a threshold of 40 stems/100 sq ft to decide if a treatment would be applied.

Performance observations. 2000. Canada thistle suppression was less than expected from all treatments. Control ratings in July were very good to excellent for clopyralid, fair to good for metsulfuron and clopyralid plus dicamba, and poor for dicamba alone. The thistle pressure ratings in October were relatively high for all treatments, with only those containing clopyralid giving reasonable suppression as evaluated by the change in relative thistle pressure from June to October. Perhaps the fact that the site had been grazed for a week immediately preceding the applications reduced translocation to the roots. The 9-hour interval between application and first rainfall should have been adequate for absorption to have occurred.

2001. Canada thistle populations in the spring of 2001 were essentially unchanged from those of 2000 reinforcing the thistle pressure levels observed in the fall of 2000. The 2001 treatments were not impacted by grazing and were much more effective as all treatments gave 88% visual control in July. Treatments with clopyralid in 2001 had the lowest Canada thistle pressure in the fall. However, Canada thistle pressure in the fall of 2001 was high for all metsulfuron treatments, indicating that this product does not offer long term control.

2002. Only consecutive applications of clopyralid and clopyralid followed by dicamba did not need retreating in 2002. Consecutive use of metsulfuron at the rate used and time applied failed to control

Canada thistle; the same was true for repeated applications of dicamba. The challenge of reducing thistle populations to acceptable levels is indeed a challenge. Modifications in treatments were made this year in that a premixture of clopyralid and triclopyr (Redeem) was used in three treatments instead clopyralid because Redeem is more economical than clopyralid (Stinger).

2003. Seven of the 12 treatments did not need herbicide this year (thistle populations in June were less than 40 stems/100 sq ft). The pattern that emerged is that two consecutive applications of products containing clopyralid resulted in relatively low thistle populations. This year a premixture of 2,4-D and clopyralid (Curtail) was used to replace metsulfuron (which at the time and rate used in this study was not effective). Next year, Curtail will be used to replace clopyralid and Redeem (Redeem is not marketed in Wisconsin) in all treatments except the one based on clopyralid as needed. Canada thistle pressure ratings in October were 2% or less for repeated dicamba application and for clopyralid or Curtail in 2003.

2004. As in 2003, several treatments were not needed in 2004. Plots within a treatment varied more in thistle density than desired and the threshold of 40 stems/100 sq ft was applied as follows: if two of the three plots averaged less than this density, herbicide was not applied. All herbicides applied in June 2004 reduced Canada thistle pressure (visual assessment) in October while the thistle abundance in all untreated plots increased. Pressure ratings in the fall were more variable than desired for some of the herbicides applied in 2004, especially for Curtail where the pressure varied from 0 to 9% within the treated plots. Curtail applied in June 2003 did not need retreating and had little Canada thistle in Oct. 2004. Dicamba plus diflufenzopyr (Overdrive which is labeled for use in pastures) was included in two of the 2004 treatments and reduced thistle pressure in October to very low levels.

Economic assessment. The costliest system was clopyralid (Stinger) used when needed (three of the five years) which cost $164/a (product plus three applications at $8/a each). The least costly systems were two applications of Stinger plus Clarity (half rates of each) followed by two applications of metsulfuron followed by one of Curtail ($93/a), and four applications of metsulfuron and one of Overdrive ($95). While $93 to $95/a may be the lowest cost, they had the most applications (four or five) and would not be recommended because metsulfuron did not give acceptable control as used in this study. Two systems that were effective and more economical than repeated clopyralid applications were Stinger in 2000 followed by Clarity in 2001 and 2004 ($108/a) and Stinger plus Clarity tank mix in 2000 and 2001 and Redeem plus Clarity in 2002 ($103/a).

Tackling Canada thistle in grazed pastures requires a long-term commitment. This trial will continue as we do not have all the answers yet.

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

Saltcedar (*Tamarix ramosissima* Ledeb.) is an invasive shrub or tree found along stream banks and waterways throughout the United States. This salt tolerant phreatophyte can reach 6 m in height, transpires nearly 300 L of water per tree per day, and decreases species richness in the habitats where it resides. In Kansas, saltcedar is particularly a problem along the Cimarron and Arkansas watersheds. Research was initiated in April 2004 on the Cimarron National Grasslands located near Elkhart, KS. A scattered stand of multi-stemmed saltcedar was cut near ground level using a 10-cm rotary saw attached on the front end of a tractor. On April 13, 100 cut-stumps were selected for herbicide treatment. Ten treatments were applied in a randomized block design with 10 replications. Herbicides were applied using hand-held garden sprayers. Treatments were rated for percent control 3 and 6 months after treatment (MAT), and for mortality 6 MAT. Treatments included an untreated check, triclopyr at 10, 24, and 48 g L^{-1} diesel, glyphosate at 18 g L^{-1} water, imazapyr at 23 g L^{-1} water, triclopyr + 2,4-D at 5 + 10 g L^{-1} diesel, a ready to use formulation of triclopyr at 90 g L^{-1}, glyphosate + 2,4-D at 18 + 23 g L^{-1} water, and glyphosate + imazapyr at 18 +12 g L^{-1} water. All untreated trees had resprouted 3 months after cutting, with resprouts up to 1.2 m tall. All herbicides provided greater than 90% control 3 MAT except those cut-stump treatments containing glyphosate. Additional resprouting occurred between 3 and 6 MAT. All treatments containing triclopyr or imazapyr provided greater than 80% control 6 MAT. The only treatment providing 100% mortality 6 MAT was the ready to use formulation of triclopyr applied at 90 g L^{-1}. These results are preliminary as evaluations will need to be made at least 1 or 2 years after treatment to fully assess herbicide effectiveness.

COMMON LAMBSQUARTERS RESPONSE TO GLYPHOSATE APPLIED AT THREE DIFFERENT GROWTH STAGES. Christopher L. Schuster, Douglas E. Shoup, and Kassim Al-Khatib, Graduate Research Assistant, Graduate Research Assistant, and Professor. Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Common lambsquarters is becoming a problematic weed in glyphosate-resistant cropping systems. Our first objective was to determine the efficacy of glyphosate on common lambsquarters from five regions around the United States at the 2.5, 7.5, and 15-cm growth stage. In addition, glyphosate absorption and translocation were determined at the same three growth stages. Common lambsquarters populations from Kansas, Nebraska, North Dakota, Ohio, and Washington were treated with glyphosate at 0, 0.125, 0.25, 0.5, 1, 2, 4, and 8 times the use rate at three growth stages. Glyphosate use rate was 1060 g ha^{-1}. Visible injury ratings and plant dry weights were determined at 14 days after treatment (DAT). Data were analyzed using nonlinear regression analysis. Herbicide rate required to inhibit plant dry weight by 40% (GR_{40}) were calculated for each growth stage of the five common lambsquarters populations. The greatest GR_{40} value at the 2.5-cm growth stage was with the Ohio population at 0.27 times the use rate whereas the least value was with the Nebraska population at 0.18 times the use rate. The greatest GR_{40} value at the 7.5-cm growth stage was with the Washington population at 0.96 times the use rate whereas the least value was with the Kansas population at 0.49 times the use rate. The greatest GR_{40} value at the 15-cm growth stage was with the Ohio population at 3.97 times the use rate whereas the least value was with the Kansas population at 0.71 times the use rate. The second objective was to determine glyphosate absorption and translocation in the Nebraska population. The second mature leaf from the top of common lambsquarters at the three growth stages were treated with ^{14}C-glyphosate. Plants were harvested 1, 3, and 7 DAT and divided into treated leaf, foliage above treated leaf, foliage below treated leaf, and roots. Plant parts were oxidized and $^{14}CO_2$ was captured and quantified using liquid scintillation spectrometry. Data were analyzed using analysis of variance. There were no differences in absorption or translocation between growth stages. At 7 DAT, common lambsquarters at the 2.5, 7.5, and 15-cm growth stage absorbed 60, 68, and 61% of the radioactivity applied, respectively. The 2.5, 7.5, and 15-cm common lambsquarters retained 89, 83, and 76% of radioactivity in the treated leaf at 7 DAT. In general, remaining radioactivity translocated equally to the foliage above treated leaf, foliage below treated leaf, and roots.

INHERITANCE OF EVOLVED GLYPHOSATE RESISTANCE IN HORSEWEED. Ian A. Zelaya, Micheal D.K. Owen and Mark J. VanGessel, Research Associate and Professor, Department of Agronomy, Iowa State University, Ames, IA 50011–1011 and Professor, Department of Plant and Soil Sciences, University of Delaware, Georgetown, DE 19947–9575.

N–(phosphonomethyl) glycine (glyphosate) resistance has evolved in several horseweed [*Conyza* (= *Erigeron*) *canadensis* (L.) Cronq.] populations within United States agroecosystems. A near–homozygous resistant population was isolated through two cycles of recurrent selection of a Houston, DE population. Susceptible and pristine horseweed populations were collected in Georgetown, DE and Ames, IA, respectively. Inheritance of glyphosate resistance in horseweed was investigated by performing reciprocal crosses between confirmed resistant and susceptible phenotypes. Segregation ratios of the first (F_1) and second (F_2) filial generations, and the backcrosses of the F_1 to the susceptible and resistant parents, suggested that glyphosate resistance in horseweed was governed by a single, incompletely–dominant, nuclear gene. Assisted crosses confirmed that while essentially autogamous, horseweed can cross–pollinate (0–15%). The simple inheritance model, the biology of horseweed, and the survival of F_1 plants when exposed to the recommended glyphosate field rate, explains the rapid evolution and large geographical distribution of glyphosate resistant horseweed populations. For further details refer to: Zelaya, I. A., M. D. K. Owen, and M. J. VanGessel. 2004. Inheritance of evolved glyphosate resistance in *Conyza canadensis* (L.) Cronq. Theor. Appl. Genet. 109: *in press*.

DIFFERENTIAL WEED SPECIES RESPONSES TO THE USE OF WATER CONDITIONERS WITH GLYPHOSATE.

Donald Penner and Jan Michael, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824-1325.

The objective of the research was to compare the responsiveness of a range of weed species to the presence of diammonium sulfate applied with glyphosate. The weed species were grown in the greenhouse. Two formulations of glyphosate were applied generally at 0.17 and 0.34 kg ae/ha with and without 2% diammonium sulfate. The spray solution was applied when the plants were 10 to 15 cm. tall. Weed species were evaluated for control 7, 10, and 14 days after treatment. Weed control in the presence of the diammonium sulfate applied with glyphosate was divided into three groups. Very responsive weed species to the addition of diammonium sulfate with glyphosate included prickly sida, venice mallow, velvetleaf, and small sized common dandelion. Intermediate in response were giant foxtail, barnyardgrass, large crabgrass, and yellow nutsedge. The least responsive weed species in the study were yellow foxtail, eastern black nightshade, ivyleaf morningglory and common lambsquarters.

WATERHEMP'S RESPONSE TO GLYPHOSATE SELECTION. Patrick J. Tranel, William L. Patzoldt, and Dean S. Volenberg. Associate Professor, Graduate Research Assistant, and Postdoctoral Research Scientist, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Glyphosate, applied postemergence, effectively controls waterhemp. Recently however, anecdotal reports from the field have suggested that waterhemp control with glyphosate is becoming less consistent. Therefore, we initiated experiments to evaluate glyphosate responses in waterhemp. Five waterhemp populations were obtained from sites near Everly, IA, Sutter, IL, St. Elmo, IL, and Altamont, IL (two populations) following reports of poor glyphosate control at those locations. Waterhemp populations were also selected based on geographic location, with the assumption that distant populations would have different genes or alleles contributing to reduced glyphosate susceptibility. Using these waterhemp populations, plus three waterhemp populations serving as glyphosate-susceptible controls, our objective was to determine if repeated cycles of glyphosate selection would lead to decreased glyphosate sensitivity. At each cycle of selection, 1000 plants were treated with glyphosate, and 100 surviving plants allowed to randomly mate to generate progeny for the next cycle. Thus far, three cycles of selection have been completed, with plants from the first two cycles (C1 and C2) treated with glyphosate at 216 g ae ha^{-1}, while plants in the third cycle (C3) were treated with glyphosate at 325 g ae ha^{-1}. Following treatment, percent injury ratings were taken 2, 4, 8, and 16 DAT. In all cycles of selection, progeny among female waterhemp lines were significantly different, suggesting that genetics play a role in glyphosate responses. During C1 and C3, significant genotype by environment interactions were identified, which are characteristic of quantitatively inherited traits. Using the glyphosate-susceptible waterhemp populations to assess the efficacy of glyphosate at each cycle, it appears that selection for decreased glyphosate sensitivity is possible. Additionally, notes were taken before glyphosate treatment in an attempt to describe the phenotypic architecture of each plant. Phenotypic ratings for lateral bud growth, leaf shape, and leaf area relative to height were assessed to determine if these traits contribute to variation of glyphosate responses. Lateral bud growth was significant in C1, C2, and C3, with plants having more lateral bud growth exhibiting significantly less sensitivity to glyphosate.

HAS WATERHEMP BECOME HARDER TO CONTROL WITH GLYPHOSATE? Dean S. Volenberg, William L. Patzoldt, Aaron G. Hager, and Patrick J. Tranel, Postdoctoral Research Scientist, Graduate Research Assistant, Assistant Professor, and Associate Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Since the beginning of this century there have been ongoing reports that waterhemp (*Amaranthus tuberculatus* (Moq) Sauer) is harder to manage with glyphosate than in the past. Therefore we quantified glyphosate responses of 100 waterhemp populations obtained from different times. The populations consisted of ten populations collected prior to 1996, 45 collected in 1998 and 1999, and 45 collected in 2003. A population consisted of seed collected from one waterhemp plant. Populations were randomly collected from soybean (*Glycine max* (L.) Merr.) or corn (*Zea mays* L.) fields throughout Illinois, except for two populations within the prior to 1996 group, which were obtained from Iowa. Two additional populations were included in experiments as positive and negative controls. Four- to five-leaf stage (10 to 12 cm) waterhemp plants grown in the greenhouse were treated with 0 or 270 g ai ha^{-1} glyphosate. Shoot biomass was harvested 14 days after treatment, dried at 70 C, and quantified. The experimental design was completely randomized for each experiment with six replicates per treatment. The experiment was conducted five times. Data were combined by population collection time and the mean responses calculated. Analysis of variance was performed on all data. Means were separated with Fisher's protected LSD at the 0.05 level of significance. The experiment by treatment interaction was significant and the data from repeated experiments is presented separately. In three of the experiments, there was no difference in the mean responses to glyphosate among populations grouped by collection time (i.e. prior to 1996 = 1998-1999 = 2003). In the other two experiments the mean response of the prior to 1996 group and 1998-1999 group were similar, whereas the 2003 group had a significantly lower mean response compared to the other two groups in one experiment and a significantly greater mean response than the prior to 1996 group in the other experiment. There were several populations within each of the three groups that were very sensitive to glyphosate. In contrast, there were also some glyphosate-tolerant populations within the 1998-1999 and 2003 collection. In follow-up dose-response experiments, four-to five-leaf stage (10 to 12 cm) plants of selected glyphosate-tolerant populations from the 1998-1999 and 2003 collections had GR_{50} values ranging from 153 to 402 g ai ha^{-1}, whereas the positive and negative control populations had an GR_{50} values of 249 and 209 g ai ha^{-1}, respectively. Our results indicate that glyphosate sensitivity has not decreased appreciably over time in these populations.

FACTORS INFLUENCING COMMON LAMBSQUARTERS CONTROL WITH GLYPHOSATE**.**
Andrew R. Kniss, Stephen D. Miller, and Robert G. Wilson, Assistant Research Scientist and Professor, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071, and Professor, Panhandle Research and Extension Center, University of Nebraska, Scottsbluff, NE 69361.

Several reports have indicated that common lambsquarters has increased in glyphosate-resistant cropping systems. Field and greenhouse studies were conducted to examine factors that influence glyphosate efficacy on common lambsquarters. Weed size at application, glyphosate rate, addition of ammonium sulfate, and genetic makeup of individuals were all shown to have a role in glyphosate efficacy. GR_{50} values indicate that tolerance to glyphosate doubles as common lambsquarters increases in maturity from the 4 true-leaf to the 10 true-leaf stage of growth. Addition of ammonium sulfate at 1.7 kg/ha to glyphosate (0.84 kg ae/ha) increased control of 10 cm common lambsquarters from 73 to 91%, and 25 cm common lambsquarters from 80 to 89%. Increasing the glyphosate rate to 1.12 kg ae/ha provided an additional increase in percent control.

PROGRESS TOWARDS UNDERSTANDING THE MECHANISM OF PPO INHIBITOR RESISTANCE IN WATERHEMP. William L. Patzoldt, Aaron G. Hager, Joel S. McCormick, and Patrick J. Tranel, Graduate Research Assistant, Assistant Professor, Undergraduate Research Assistant, and Associate Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

In 2001, a waterhemp population with resistance to protoporphyrinogen oxidase (PPO)-inhibiting herbicides was identified in Adams County, Illinois. Crosses were conducted among plants from a line derived the Adams County, IL waterhemp population that were uniformly resistant to PPO inhibitors (R parent) and a waterhemp biotype that were susceptible to PPO inhibitors (S parent) to create F_1 lines. F_1 plants were crossed among themselves to generate F_2 lines, or to plants from the R or S parental biotype to create backcrossed (BC) progeny. Following treatment of F_2 and BC progeny with lactofen at 110 g ai ha^{-1} plus 1% (by vol) COC, segregation of resistant and susceptible responses suggested that PPO inhibitor resistance was inherited as a single nuclear gene. Herbicide dose-response experiments with F_1 progeny, when compared with R and S parents, suggested that resistance to either lactofen or acifluorfen was incompletely dominant. The genes encoding both the plastid and mitochondrial PPO isozymes, *PPX1* and *PPX2*, respectively, were sequenced and compared from multiple plants of R and S parental biotypes. Interestingly, *PPX2* was identified in two isoforms, a short form (*PPX2S*) whose translation product encodes a mitochondrial PPO, and a long form (*PPX2L*) whose translation product encodes a mitochondrial PPO with a chloroplastic transit peptide sequence. PCR-based molecular markers were developed capable of identifying *PPX* alleles from either the R or S parental biotypes in segregating waterhemp lines. The *PPX* allele-specific PCR markers are being used to determine if *PPX1* or *PPX2L* correlate with resistant and susceptible lactofen responses in BC progeny.

EFFECT OF GLUFOSINATE AND THE GENE GDHA ON THE METABOLIC PROFILE OF TOBACCO. Scott A. Nolte, Luke T. Tolley, Bryan G. Young and David A. Lightfoot, Graduate Research Assistant, Assistant Professor, Associate Professor and Professor, Southern Illinois University, Carbondale, IL 62901.

Glufosinate inhibits the glutamine synthetase enzyme, thereby causing ammonia toxicity in susceptible plants. A secondary pathway for ammonium assimilation is catalyzed by glutamate dehydrogenase (GDH). An isolated *gdh*A gene from *E.coli* which encodes for a more active GDH pathway was used to transform plants which resulted in an increase in tolerance to glufosinate. Therefore, *gdh*A transformed plants exhibit a novel mechanism of tolerance to glufosinate via greater activity of the GDH pathway. To further elucidate the changes caused by gene transformation and herbicide application, metabolic profiling techniques were utilized.

Two tobacco lines including *gdhA* transgenic and a non-transformed control were treated with 340 g ai/ha glufosinate. Two days after treatment leaves and roots from treated as well as non-treated plants were harvested and tissue extractions were performed. Tobacco samples were analyzed using a Q-Tof micro mass spectrometer, in the positive ion mode. Spectra were acquired every second with a mass range of 100 to 1200 daltons. Data was collected for 5 minutes and then summed for the final spectra.

ESI-MS detected over 1,300 ions in both leaves and roots combined. Through manual deconvolution over 300 ions were discovered in roots and over 200 ions in leaves that changed in abundance due to transformation with the *gdhA* gene. Approximately 18 and 15 of the changed metabolites from roots and leaves, respectively, were in the range of 100-200 daltons, which are possibly amino acids or derivatives. There also were over 300 ions in roots and over 300 ions in leaves that changed in abundance due to the application of glufosinate. Use of metabolic profiling is a tool to assess how plant transformations for herbicide tolerance and subsequent application of that herbicide alter plant metabolic processes.

ACTIVITY OF PHOTOSYSTEM II INHIBITORS IN COMBINATION WITH MESOTRIONE ON TRIAZINE-RESISTANT AND SENSITIVE AMARANTHUS SPP. 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.

Current weed management practices frequently utilize combinations of herbicides with different modes of action to broaden the weed control spectrum and reduce the likelihood of herbicide resistance evolution. Combining mesotrione with photosystem II (PSII)-inhibiting herbicides, such as atrazine, has demonstrated enhanced weed control, possibly through a synergistic interaction. Greenhouse studies were conducted in which single and paired herbicide treatments were applied to four biotypes of *Amaranthus spp.*: triazine-sensitive and triazine-resistant waterhemp (*Amaranthus tuberculatus*) and triazine-sensitive and triazine-resistant redroot pigweed (*Amaranthus retroflexus*). Dose-response curves were generated for each herbicide and each biotype, and percent growth reduction was used to determine the most appropriate rates to use for joint treatments of atrazine plus mesotrione. Rates of atrazine ranged from 0.6g ai ha^{-1} to 1633g ai ha^{-1}, and rates of mesotrione ranged from 0.7g ai ha^{-1} to 561g ai ha^{-1}. Combinations of mesotrione and atrazine were applied such that the lowest rates of each herbicide were paired, and continued through pairing of the highest rates of the two herbicides. Dry weight data, taken two weeks after treatment, were then statistically analyzed to determine the nature of the interaction between the two herbicides. Based on the levels of injury that were biologically achievable (less than 100 percent growth reduction), only combined rates below the GR_{50} for each herbicide were analyzed using a method previously described by Colby. Synergistic, antagonistic, and additive effects between atrazine and mesotrione were displayed among the four *Amaranthus* biotypes, revealing an inconsistency among biotypes and application rates in the nature of the interaction. This variability may indicate that the joint action of atrazine and mesotrione is dose-dependent. Additional studies were initiated to further investigate joint action of atrazine and mesotrione, as well as investigate the activity of other PSII-inhibiting herbicides combined with mesotrione in triazine-sensitive and triazine-resistant redroot pigweed. Rates of PSII inhibitors were based on fractions of the field usage rates of atrazine, metribuzin and bromoxynil. A full field usage rate of each herbicide was applied, as well as one-third, one-tenth, and one-twentieth of the full rate. Herbicide rates ranged from: atrazine, 112g ai ha^{-1} to 2242g ai ha^{-1}; metribuzin, 16g ai ha^{-1} to 315g ai ha^{-1}; and bromoxynil, 17g ai ha^{-1} to 341g ai ha^{-1}. The same treatments of atrazine, metribuzin, and bromoxynil were also paired with a GR_{50} rate of mesotrione, 42g ai ha^{-1}. Visual results from this experiment indicate a more pronounced synergism between treatments combining mesotrione and bromoxynil in both biotypes of redroot pigweed, compared with treatments of mesotrione combined with either atrazine or metribuzin.

DENATURING HPLC EFFICIENTLY DETECTS MUTTION OF THE ACETOLACTATE SYNTHASE GENE. Balazs Siminszky, Nicholas P. Coleman and Mariam Naveed, Professor, Research Analyst and Student, Agronomy Department, University of Kentucky, Lexington, KY 40546-0312.

Acetolactate synthase (ALS), a common enzyme in the biosynthesis of branched-chain amino acids, is a target for the sulfonylurea, imidazolinone, triazolopyrimidine, pyrimidinylthiobenzoate and the sulfonylaminocarbonyltriazolinone classes of herbicides. Widespread resistance to the ALS-inhibiting herbicides has been attributed to single base mutations in the ALS gene. The objective of this study was to investigate the feasibility of employing denaturing high performance liquid chromatography, a recently developed method of mutation analysis, for the detection of three ALS mutations, $Ala_{122}Thr$, $Leu_{574}Trp$ and $Ser_{653}Thr$, which confer herbicide resistance. The mutated variants of the ALS gene were isolated from herbicide-resistant biotypes of smooth pigweed and powell amaranth using polymerase chain-reaction (PCR). The PCR products were hybridized with a wild-type sample and subjected to DHPLC analysis. All three mutations could be detected using a modified HPLC system; however, the sensitivity of the method was strongly dependent on the melting temperature profile of the analyzed DNA fragment. Once the primers and the DHPLC conditions are optimized, the procedure is economical, rapid and requires little sample preparation. Due to these favorable features, DHPLC can be used as an alternative to other commonly used mutation detection methods.

EXAMINING THE POTENTIAL ROLE OF ISOXADIFEN-ETHYL AS A SAFENER FOR VARIOUS POSTEMERGENCE CORN HERBICIDES. Jeffrey A. Bunting, Dean E. Riechers, and Bill Striegel. Seed Agronomist, GROWMARK, Bloomington, IL 61702, Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801, and Field Development Representative, Bayer Crop Science, Normal, IL 61761.

Two field studies were conducted at Bloomington, DeKalb and Urbana, IL in 2004 to 1) evaluate crop response when isoxadifen-ethyl is used with other postemergence corn herbicides and 2) determine the effects of foramsulfuron with and without a safener when tank-mixed with an organophosphate insecticide. The herbicide treatments included foramsulfuron plus isoxadifen-ethyl tank-mixed with rimsulfuron, dicamba plus diflufenzopyr, mesotrione, dicamba, or nicosulfuron plus rimsulfuron. Additional treatments included only isoxadifen-ethyl tank-mixed with rimsulfuron, dicamba plus diflufenzopyr, mesotrione, dicamba, or nicosulfuron plus rimsulfuron. Since the use of a methylated seed oil (MSO) is not recommended with these herbicides due to the potential for corn injury, our objective was to determine if isoxadifen-ethyl would safen corn from injury caused by these herbicides when used with a MSO. Two corn hybrids with different levels of tolerance were chosen for the first study to obtain maximum corn injury and plots were kept weed-free to eliminate any competition from weeds. All herbicide applications were made when corn plants were at the V6 growth stage. All herbicides were applied at the 1X labeled field use rates. Among the herbicides tested, only dicamba and dicamba plus diflufenzopyr resulted in less crop injury when tank-mixed with isoxadifen-ethyl, compared with the same herbicide without isoxadifen-ethyl with both hybrids (Pioneer P33K81 and P33P66) 7 days after treatment. The addition of isoxadifen-ethyl resulted in less crop injury when tank-mixed with rimsulfuron with only the P33K81 hybrid. There was no significant difference in adding isoxadifen-ethyl with mesotrione or nicosulfuron plus rimsulfuron. The addition of isoxadifen-ethyl partially protected corn from the response of mesotrione, nicosulfuron plus rimsulfuron, dicamba, dicamba plus diflufenzopyr, and rimsulfuron when treatments included an organophosphate insecticide, chlorpyrifos. Most postemergence corn herbicides recommend applying an organophosphate insecticide at least 7 days before or 3 days after the herbicide. The use of isoxadifen-ethyl may reduce the level of crop injury when a treatment of an insecticide is needed at the time of the corn herbicide application. With the increase in transgenic corn hybrids with rootworm protection, the use of foliar applications of organophosphate insecticides may increase to control secondary pests. The use of the first foliar-applied corn safener, isoxadifen-ethyl, may give more application flexibility when using these insecticides in combination with postemergence herbicides in corn.

VARIATION IN HERBICIDE RESPONSE AMONG EASTERN BLACK NIGHTSHADE AND HAIRY NIGHTSHADE POPULATIONS IN MICHIGAN. Vijaikumar Pandian* and Bernard H. Zandstra, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Weeds in the nightshade family (*Solanaceae*) are difficult to control in solanaceous vegetable production. Greenhouse experiments were conducted in 2003 and 2004 to determine the variation in response to herbicides among eastern black nightshade, hairy nightshade and horsenettle populations collected in Michigan. Among the 11 populations of eastern black nightshade screened for herbicide dose response, the Ingham2 population had more tolerance than the other populations to sulfentrazone, metribuzin and halosulfuron. The Macomb3 eastern black nightshade population was significantly more susceptibility to halosulfuron (GR_{50}= 0.01 kg/ha) than the other eastern black nightshade populations. The Oceana1 eastern black nightshade population had a higher tolerance to sulfosulfuron than the other eastern black nightshade populations. A wide range of tolerance was observed among 11 eastern black nightshade populations in response to metribuzin, where the Monroe4 population had the least tolerance to metribuzin (GR50=0.28 kg/ha). There was a wide range of variation among five populations of hairy nightshade in response to halosulfuron. Bay2 and Macomb1 hairy nightshade populations were more tolerant than other hairy nightshade populations to halosulfuron. There was no significant difference in herbicide sensitivity among horsenettle populations.
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EFFECT OF HAIRY VETCH (VICIA VILLOSA) RESIDUE ON WEED SPECIES COMPOSITION IN PICKLING CUCUMBER. Erin C. Hill and Mathieu Ngouajio, Student and Assistant Professor, Department of Horticulture, Michigan State University, MI 48824-1325.

Hairy vetch (*Vicia villosa* Roth) is a legume cover crop used in diverse cropping systems for its ability to fix nitrogen and improve soil quality. Hairy vetch (HV) has been shown to control weeds by the release of allelochemicals from its residues. However, if the cash crop is planted too soon after the incorporation of HV, it can be injured by these allelochemicals, leading to reduced yields. In the summer of 2003, a split plot experiment with four replications was conducted at the Horticulture Teaching and Research Center at Michigan State University, East Lansing, MI, to (1) study the potential of HV to suppress weeds and (2) determine if the timing of cucumber planting after HV incorporation affects cucumber growth and development. The main plot factor was cover crop with two levels (HV and bare ground) and the subplot factor was cucumber planting date with six levels. Cucumbers 'Vlaspik' were planted at 0, 1, 2, 3, 4, 5, and 6 weeks after HV incorporation (WAI). Weed counts and dry biomass were measured at 3 and 6 weeks after cucumber planting (WAP). The main weed species found on both dates were redroot pigweed (*Amaranthus retroflexus* L.), yellow rocket (*Barbarea vulgaris* R. Br.), shepherd's purse (*Capsella bursa-pastoris* L.), common lambsquarters (*Chenopodium album* L.), quackgrass (*Elytrigia repens* L.), henbit (*Lamium amplexicaule* L.), common purslane (*Portulaca oleracea* L.), and common chickweed (*Stellaria media* L.) Of these weeds, only quackgrass density was significantly reduced by the HV cover crop. Quackgrass densities were 71 plants m^{-2} and 20 plants m^{-2} at 3 WAP in the bare ground control and HV plots, respectively. At 6 WAP, quackgrass densities were 68 plants m^{-2} and 8 plants m^{-2} for bare ground and HV, respectively. Total weed biomass was not affected by HV residues. It is likely that the density of other weed species and the total weed biomass were not affected due to leaching of allelochemicals by heavy rains that occurred during the experiment. Cucumber stand, vine weight at harvest, and fruit yield were lowest when planted immediately after HV incorporation. This study indicates that HV may be used in cropping systems to improve control of quackgrass, a troublesome perennial weed in many crops. However, growers should avoid planting of cucumber immediately after HV incorporation.

GLYPHOSATE-RESISTANT CROP EFFECT ON WEED DYNAMICS IN WHEAT. George O. Kegode and Mark G. Ciernia, Assistant Professor and Research Specialist, North Dakota State University, Fargo, ND 58105.

Weed species diversity and density in wheat was evaluated for the initial 3 yr of a long-term weed management experiment initiated near Fargo, North Dakota, in 2002. This experiment is designed to study weed population dynamics in glyphosate-resistant corn, glyphosate-resistant soybean, and conventional wheat cropping systems. The cropping systems and associated weed control were (i) conventional, with one postemergence herbicide treatment plus preplant and postharvest tillage; (ii) conventional, with two or more postemergence herbicide treatments plus preplant and postharvest tillage; and (iii) no-till, with preplant and one postemergence herbicide treatments. The study was a randomized complete block with three replicates, and treatments were established in the first year such that each crop within a system was present each year. Spring wheat was seeded in 2002 where conventional soybean was grown in 2001, and was seeded in 2003 where glyphosate-resistant soybean was grown the previous year. In 2004, spring wheat was seeded where glyphosate-resistant soybean was seeded in 2003 and glyphosate resistant corn in 2002. Weed composition and density were evaluated in wheat prior to planting, at herbicide treatment, and post-harvest from ten randomly placed 0.1-m^2 quadrats within each plot. Common lambsquarters, dandelion, green and yellow foxtail, kochia, prostrate spurge, redroot pigweed, wild buckwheat, wild mustard, and volunteer soybean comprised 92% of weeds across evaluation times in 2003. In 2004, the diversity of weed species that comprised greater than 90% of the total population remained largely the same except for dandelion and wild mustard, which were largely replaced by common purslane and Venice mallow. In 2002, 11, 76, and 7% of the weeds in wheat were present before planting, when herbicides were applied, and post-harvest, respectively. In 2003 and 2004, greater than 97% of the weeds in wheat were present when herbicides were applied. In 2002, greater than 50% of weeds were in the no-till regime regardless of evaluation time, whereas in 2003 and 2004, weeds were evenly distributed among tillage regimes when herbicides were applied. Total weed densities in wheat were 677, 186, and 86 plants m^{-2} in 2002, 2003, and 2004, respectively. The low weed densities in 2003 and 2004 may have been due to effective weed control in glyphosate-resistant crops and early wheat seeding.

INFLUENCE OF WEED MANAGEMENT TREATMENTS ON SOIL SEED BANK DYNAMICS. Gustavo M. Sbatella and Stephen D. Miller, Graduate Assistant, Professor, Department of Plant Sciences, University of Wyoming, Laramie, WY, 82071.

Weed seeds that persist in the soil seed bank are the main source of weed infestations in agricultural fields. Weed seed bank dynamics are complex and are influenced by tillage practices, crop rotations and herbicides. In 2002 and 2003 a study was conducted at the Research and Extension Center, Torrington, WY to evaluate the impact of different weed control treatments in a corn (*Zea mays* L.) /sugarbeet (*Beta vulgaris* L.) or barley (*Hordeum vulgare* L.) /sugarbeet rotation on soil seed bank dynamics.

Common lambsquarters (*Chenopodium album* L.), hairy nightshade (*Solanum sarrachoides* Sendtner) and redroot pigweed (*Amaranthus retroflexus* L.) accounted for 90% of the total weed seed in the soil seed bank. Samples collected after corn or barley harvest showed no significant impact in total seed numbers due to herbicide treatments; however, differences were evident in samples collected following sugarbeet harvest. Glyphosate or the conventional treatment (ethofumesate + triflusulfuron + phenmediphan / desmediphan / ethofumesate + clopyralid) in sugarbeet reduced the total number of weed seed in soil following all corn treatments, mainly due to their impact on redroot pigweed and hairy nightshade. An increase in soil seed bank numbers was observed when the micro-rate treatment was used in sugarbeet after all of the barley treatments. None of the sugarbeet treatments were able to reduce total seed numbers following untreated plots in barley or corn. Common lambsquarters seed bank numbers increased with all treatments in barley suggesting barley provided a more favorable community for this species.

INFLUENCE OF TILLAGE AND CROP ON GIANT RAGWEED EMERGENCE, SEED DISTRIBUTION AND LONGEVITY. Dawn E. Nordby, Martin M. Williams II, Extension Specialist, Department of Crop Sciences, University of Illinois, Urbana, IL 61801, and Ecologist, USDA-ARS, Urbana, IL 61801.

Field studies were conducted in 2003 and 2004 at the Northern Illinois Agronomy Research Center at Dekalb, Illinois to determine the effect of tillage and crop on giant ragweed (*Ambrosia trifida*) emergence and seed distribution in the soil. Soil samples were collected in the fall to depth increments of 0 to 2cm, 2 to 6cm, 6 to 12cm, and 12 to 20cm to determine the seed distribution in the soil profile. Natural populations of giant ragweed were monitored for emergence throughout the growing season in established no-till and conventional tillage plots. Additions of giant ragweed to the seedbank have not been permitted since the initiation of the experiment. Conventional tillage was found to have no effect on distribution of giant ragweed seed in the soil in 2002, however in 2003, there was significantly less seed in the 0 to 2cm depth in the tilled treatment compared to the other depths in the same treatment. There was no difference in seed distribution in the no-till treatments in both years. The effect of tillage on giant ragweed emergence was not significant. Crop did affect emergence with soybeans having significantly less giant ragweed emergence than corn. There was also no crop by tillage interaction. This study will be continued to determine long-term effects of tillage and crop on giant ragweed emergence. Long-term evaluation of this study will be beneficial in developing tactical approaches to controlling giant ragweed.

THE EFFECTS OF CULTURAL PRACTICES ON NIGHTSHADE COMPETITION WITH PROCESSING TOMATOES. Abram J. Bicksler and John B. Masiunas, Graduate Research Assistant, Department of Natural Resources and Environmental Sciences, University of Illinois Urbana-Champaign, Urbana, IL 61801 and Associate Professor, Department of Natural Resources and Environmental Sciences, University of Illinois Urbana-Champaign, Urbana, IL 61801.

In field experiments, the effects of rye cover cropping and staking on tomato (*Lycopersicon esculentum*) and *S. ptycanthum* competition were investigated. In 2003, nightshade interference decreased total tomato yield. Rye cover cropping reduced nightshade growth but also reduced total tomato yield by half compared to conventional tillage. In 2004, nightshade presence did not affect tomato yield, but rye again decreased total yield. The percentage of Grade A tomatoes in 2004 was greatest and the percentage of culls was lowest in the rye cover crop treatment. In 2004, staking increased tomato height, but did not consistently elevate tomato plants above nightshade plants. Staking seems to be ineffective as a means to minimize the competition of nightshades in tomatoes, and the utilization of a rye cover crop in our heavy Midwest soils reduces both nightshade and tomato growth and tomato total yields while increasing fruit quality.

GIANT RAGWEED INTERFERENCE IN CORN: IMPACT OF N RATE AND APPLICATION TIMING. Eric J. Ott, William G. Johnson, and Reece A. Dewell, Graduate Research Assistant, Assistant Professor of Weed Science, Research Associate in Weed Science, Department of Botany and Plant Pathology Purdue University, West Lafayette, IN 47907-2054.

Environmental concerns regarding the use of nitrogen fertilizer and soil-applied herbicides such as atrazine, and the adoption of glyphosate-resistance corn hybrids will likely cause changes in the dynamics of weed interference in corn. Giant ragweed (GRW) is a highly competitive weed that commonly infests crop production fields in the Midwest. GRW has the ability to emerge throughout the early growing season making it difficult to control with just a single herbicide application. Previous research evaluating the influence of N application timings and giant ragweed removal timings in corn has not been published. A field experiment was conducted at the Purdue University Agronomy Center for Research and Education. Treatments were established in a split plot design with four replications. Three nitrogen treatments (200 kg/ha before planting (BPLT), 200 kg/ha side dressed (SIDE), and 100 kg/ha BPLT + 100 kg/ha SIDE (SPLIT)), assigned to the main plots and four GRW removal timings (weed free, 10-cm, 40-cm, and season long) were assigned to the subplots. GRW plants were allowed to emerge with the corn, and GRW density was established at 0.5 plants/1m^2 at V4 corn and maintained until the appropriate removal timing. Weed free plots were maintained throughout the growing season by hand weeding at biweekly intervals. Corn was then harvested for grain and yields were then converted to 15.5% grain moisture.

Results show allowing GRW to reach 40-cm before removal results in significant reductions in the amount of N in the soil regardless of N fertility regime. Higher corn yields were observed in the SIDE and SPLIT N fertility regimes than in the BPLT when GRW interference periods were pooled together. Corn yields were similar for all N fertility regimes at the weed free and 10-cm GRW removal timings. Yield was significantly lower at the 40-cm GRW removal timing with the BPLT N fertility regime when compared to the SIDE and SPLIT N fertility regimes. Knowing how GRW interferes with corn in different N fertility regimes may play an important role in reducing herbicide and N inputs in corn production in the Midwest.

GIANT RAGWEED INTERFERENCE AMONG CROPPING SYSTEMS. Jerron T. Schmoll, Emilie E. Regnier, and S. Kent Harrison, Research Associate, Associate Professor, and Professor, The Ohio State University, Columbus, OH 43210.

Studies were conducted to determine the potential of cropping systems to minimize giant ragweed establishment and competition. Cropping systems were established in 2000 in a field with a heavy giant ragweed population and consisted of a factorial combination of tillage (no-tillage vs. chisel plow), crop species (corn, soybean, fallow), and giant ragweed management (weedy, weed-free for 3-5 weeks after crop planting, and weed-free during the entire season). Giant ragweed cumulative seedling emergence was determined in the fifth year of the study (2004) as an indication of the relative seed bank size resulting from the previous four years of continuous cropping for each of the 18 different cropping systems. As expected, giant ragweed emergence in 2004 was reduced most (over 88%) in the weed-free treatment compared to the weedy treatment regardless of crop (corn, soybean, or fallow). Maintaining the field free of giant ragweed for 3-5 weeks reduced emergence in 2004 about a third (27 to 34%) in corn and soybean compared to the weedy treatment but had no effect in the fallow treatment, indicating that in the absence of competition, seed return by giant ragweed populations was not affected by a delay in emergence of up to five weeks. Giant ragweed emergence was 33 to 52% lower in soybean than in corn, averaged over giant ragweed management treatments, and the reductions were greater in no-tillage than in chisel-plow. The difference between the two crops may have been the result of faster canopy cover by soybean, and the stimulatory effect of N on giant ragweed growth in the corn crop. Giant ragweed populations were especially high in continuous no-tillage corn, due to reduced crop stand and vigor associated with accumulation of insect pests, particularly the common corn borer, and the addition of N. Although giant ragweed produces relatively few seed in comparison to other broadleaf annual weeds, and seeds are short-lived (approximately six years) and severely predated by rodents, severe and sustained control measures are required to reduce seed return and significantly impact emergence in subsequent years. There was no evidence that no-tillage reduced giant ragweed populations, despite the greater vulnerability of seeds to predation when left on the soil surface. Four years of continuous prevention of seed return reduced emergence by 90% in conventional tillage and 84% in no-tillage compared to emergence in the first year of the study. In the 3-5 weeks weed-free treatment, giant ragweed emergence in 2004 was reduced 18% in conventional tillage compared to emergence in 2000, while in no-tillage emergence increased 248%.

WEED POPULATION DEVELOPMENT OVER TWO YEARS OF SITE SPECIFIC WEED MANAGEMENT. Jeffrey W. Vogel, J. Anita Dille, Phillip W. Stahlman, Robert E. Wolf, Graduate Research Assistant, Assistant Professor, Professor and Assistant Professor, Kansas State University, Manhattan, KS 66506.

To reduce cost associated with sampling for site specific weed management (SSWM), it is suggested that if weed populations remain constant in time and space, one intensive weed population survey could be used for future SSWM decisions. The objectives of this study were to describe weed species composition and evaluate total herbicide usage and evaluate temporal and spatial stability of weed populations through several years of SSWM. A field study was initiated in 2003 and repeated in 2004 at the Department of Agronomy Ashland Bottoms Research Farm located near Manhattan, KS. Soybean was planted and a premix of flufenacet and metribuzin was applied preemergence in 7.62 m wide strips at 0, 0.33, 0.67, and 1x the recommended rate. Prior to the postemergence application, 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 cell that was superimposed on the field and the quadrat represented the population for that grid cell. Each PRE strip was split into a site specific treatment using the optimal economical herbicide rates assigned to each cell and a random treatment in which a strip of 3 cells randomly received 0, 0.5, 0.75, and 1x the recommended rate. Weed counts were taken 3 weeks after treatment in each year. Overall the percent of quadrats with weeds present and mean density (# m^{-2}) were greater for almost every weed species in 2004 as compared to 2003. In response to the weed populations, SSWM using the optimal economic herbicide rate required treatment of 10 and 56% of the area and used only 8 and 40% of the herbicide as compared to an uniform 1x application across all PRE herbicide strips in 2003 and 2004, respectively. Temporal stability based on correlation coefficients were strong between PRE03 and PRE04 surveys and between POST03 and PRE04 surveys in the 0 and 0.33x PRE strips for key weed species. Spatial dependence, or patchiness, was low for key weeds emerging through any rate of PRE herbicide, while it was species specific at 0x PRE.

ECONOMIC EVALUATION OF SITE-SPECIFIC HERBICIDE APPLICATION. J. Anita Dille, Tyler W. Rider, Jeffery W. Vogel, and Kevin C. Dhuyvetter, Assistant Professor, Department of Agronomy, Graduate Research Assistant, Department of Agricultural Economics, Graduate Research Assistant, Department of Agronomy, and Professor, Department of Agricultural Economics, Kansas State University, Manhattan, KS 66506.

It is known that weed pressure is not regular across a field and thus, the uniform application of herbicides to spatially variable weed populations in fields means that some areas receive the correct amount of herbicide, other areas of the field receive excess herbicide when there are no weeds present to warrant it, and still other areas of the field with high weed pressure receive too little herbicide. Variable rate technology allows producers to apply such inputs at the appropriate rates where needed. In this study, an algorithm was developed to determine economic optimal postemergence herbicide rates, models were created to determine the impact that variable postemergence rates have on crop yield, and same models used to determine whether the additional costs of site-specific herbicide application were recovered. A total of five fields across Kansas were studied in 2003: two cooperator corn fields and on-station, one soybean and two grain sorghum fields. Preemergence herbicide was applied in strips (0, 1/3, 2/3, and 1X of recommended) on the grain sorghum and soybean fields. Weed species were identified and counted in 1-m^2 quadrats on a regular 7.6 x 7.6 m grid. The site-specific postemergence herbicide decision algorithm was developed to solve for an economic optimal herbicide rate for each grid-cell in the field area. This was based on estimating yield loss caused by weed pressure within each grid-cell and the expected response of weeds to herbicide application rate. The site-specific herbicide rate and four standard herbicide rates (0 to 1X of recommended rate) were applied to half of each preemergence strip using a split-plot design. Weed counts taken three weeks after application found that the site-specific treatment controlled the weeds present in the fields. Finally, crop was harvested and grain yield recorded using a yield monitor. The yield models estimated from the data from the portions of the field where standard postemergence herbicide rates were randomly applied indicated that the postemergence herbicide application had a positive but insignificant yield impact. The $13.99/ac average difference in estimated profit between site-specific and uniform full label rate applications covers all costs associated with adopting site-specific postemergence herbicide application.

CREATING A NEW INBRED. James R. Larkins, Line Development Breeder, Monsanto Company, 1051 Landsdowne Ave., Greenville, OH 45331.

Inbred line development in corn depends upon two concurrent activities: inbreeding, and testing. It requires six to eight years to develop a new commercial inbred. The process can be thought of as a pipeline beginning with choice of parents, recombination, followed by six to seven generations, of inbreeding, testing, and selection. This time frame is dependent on the use of multi-season nurseries.

Inbreeding begins by creating source variation for selection by making new crosses among existing inbreds. Breeding objectives, accumulated information, and breeder experience are all brought to bear on choosing parents of the development cross. The F2 is the first generation in which progeny plants are culled based on heritable differences. During the ear-to-row inbreeding process, selection among rows becomes more effective than selection among plants within rows. Prior to testing, selection is limited to culling for highly heritable traits such as chlorophyll mutations, disease reaction, herbicide reactions, plant type, and ear morphology.

Testing is the primary basis for selection among putative inbreds. The value of an inbred is determined by its performance in F1 hybrid crosses, which are evaluated in yield trials. Yield testing is the rate-limiting step in developing a commercial inbred. It is expensive and can only be conducted once a year in temperate regions. Furthermore, testing must be conducted over a sufficient number of seasons and sites to adequately characterize performance.

Plant breeding is a numbers game. Increasing the number of lines increases the odds of occurrence of a truly superior segregate. Increasing the number test plots per line improves the chances of recognizing it. Since testing is a limiting factor, a key strategy is to allocate resources effectively with a fixed number test plots. A tradeoff exists between deriving more inbreds with less information per line versus fewer inbreds with more information per line. A successful strategy strikes an optimum balance between number of lines and information per line to maximize the rate of gain.

TOOLS USED BY PLANT BREEDERS TO ENABLE THE DEVELOPMENT OF NEW SEED PRODUCTS. Sam R. Eathington; Breeding Applications Lead, Monsanto, 3302 SE Convenience Blvd., Ankeny, IA 50021

Plant Breeding is a long established discipline that has delivered remarkable improvements in commodity crops. To sustain the long-term improvement in commodity crops, plant breeders continue to improve the methodologies used to develop new hybrids and cultivars. In the last 20 years, scientists have demonstrated that DNA based molecular markers can improve plant breeding methodologies. Monsanto has integrated DNA based breeding tools into our global plant breeding programs. These new tools improve the selection efficiency in our plant breeding programs and enable development of new hybrids and cultivars. This presentation will outline some of the key components required to effectively use molecular marker information in a large scale breeding program and some of the DNA based breeding tools used in Monsanto's breeding programs.

INFLUENCING WEED MANAGEMENT STRATEGIES THROUGH STUDIES ON HYBRID BY HERBICIDE INTERACTIONS AND HERBCIDE TOLERANT TECHNOLOGIES. Wayne Fithian, Gary Beland, Thad Haes, Chad Kalaher, Nick Schneider, Rick Smelser, and Brent Tharp, Golden Harvest, Waterloo, 68069.

Herbicide crop safety studies are components of corn product evaluation programs of some seed companies. These studies are typically designed to identify hybrid/herbicide combinations that demonstrate potential yield loss. Some seed companies conducting this work provide sales staff and customers with herbicide safety ratings for their genetics. Information from these herbicide safety trials may be used to address aspects of herbicide management beyond hybrid-herbicide crop safety ratings. The system employed by Golden Harvest demonstrates additional contributions these trials can have on weed management objectives.

Golden Harvest has been conducting corn herbicide crop safety studies since 1983. These studies are conducted at multiple locations throughout the Corn Belt; plots are kept weed-free to eliminate the influence of weed efficacy differences among herbicides tested. Herbicide programs are chosen based on popularity, and herbicide use rates are selected based on the most commonly used rate within label recommendations. Herbicide ratings are determined based on grain yield response and are provided only for those programs tested. Generalization across herbicide families is avoided; Golden Harvest data have consistently shown differences in hybrid safety among herbicides of similar modes-of-action.

Currently used soil-applied herbicides have shown no long term crop safety differences among programs tested and have revealed very few hybrid-by-herbicide interactions. Conventional post emergence herbicide studies, however, have consistently shown hybrid-by-herbicide interactions. Environment can also strongly influence hybrid response to these herbicides, but hybrid sensitivity differences are real and should be considered in an overall management plan. Most herbicide programs are tested at more than one crop stage or height to determine how application timing can be used to reduce yield loss with sensitive hybrid/herbicide combinations.

Crop safety studies on herbicide tolerant seed products determine hybrid/variety response to soil-applied and/or tank-mix herbicide partners used to compliment weed control in a herbicide tolerant cropping system (i.e. conventional herbicides used with glyphosate on glyphosate tolerant corn). Soil-applied herbicides and tank-mix partners provide important weed management support and help reduce risk of weed escapes. Golden Harvest herbicide research has revealed minimal yield loss risk associated with soil-applied and tank-mix partners used with glyphosate in glyphosate tolerant corn and soybeans.

Golden Harvest combines research trends with herbicide use recommendations and weed efficacy performance information from universities and crop protection companies to develop weed management guidelines. The goals of these guidelines are to provide growers sustainable herbicide management options that control weeds and reduce risk while maximizing productivity.

PLANT BREEDING AND PLANT SELECTION WITH TRANSGENES. Thomas J. Peters, Monsanto Company, Chesterfield, MO 63017.

Genetic modification or genetic engineering involves the transfer of genes from one organism to another. Gene transfers from plants of the same species or closely related species has occurred throughout the course of plant evolution and are the basis for the crop improvement. Gene transfers between very different organisms has provided scientists the opportunity to genetically tranform plants and create plants with tolerance to herbicides, protection from insects and to potentially modify plant yield or seed composition.

Agrobacterium-mediated plant transformation is one of several methods to incorporate desirable traits into plants. DNA carrying the desired gene or trait is inserted into the tumor-inducing plasmid of the bacterium and is transferred to the cell nucleus and integrated into the chromosome following infection. All cells carry the new gene or trait when a plant is regenerated from a single cell following regeneration.

Plant Breeders evaluate plants derived from transformation to identify plants with the best combination of molecular characterization, expression/efficacy and agronomic evaluation. Transgenes usually are single dominant genes that follow Mendelian segregation ratios. That is, a 3:1 ratio (phenotype) in the self-pollination generation and a 1:1 ratio in the backcrossing generation. Efficacy is the phenotypic expression of the gene of interest and can be influenced by copy number, intactness of the insert and position in the genome. Agronomic experiments are conducted to ensure that the transgene does not have a deleterious affect when evaluated in a trait neutral environment compared to its non-transformed parent or gene negative isoline.

IMPACT OF FUTURE SEED TECHNOLOGY ON THE PESTICIDE INDUSTRY. Michael S. DeFelice, Senior Marketing Manager, Pioneer Hi-Bred International, Johnston, IA 50131.

Transgenic herbicide and insect resistance technology has already had a dramatic impact on the pesticide industry since the mid 1990s. Herbicide resistant corn, soybean, canola, and cotton accounted for 73%, or 49.7 million ha of the 67.6 million hectares of transgenic crops in the world in 2003 according to the International Service for the Acquisition of Agri-biotech Applications (ISAAA). Insect resistant *Bacillus thurigiensis* (Bt) crops accounted for 18%, or 12.2 million hectares of the 67.6 million hectares of global transgenic crops in 2003. The global market value of transgenic crops was estimated at $4.5 to $4.75 billion in 2003. The global rate of adoption of these technologies is expected to continue to increase dramatically according to the same report.

Insect resistant transgenic crops have often resulted in direct substitution for insecticides, and are expected to continue to do so in the future. This has had a negative impact on the size of the insecticide market. However, insecticides will still be needed to provide resistance management options, fill gaps in the spectrum of insects controlled, and provide control of insects in smaller market areas that are not addressed by transgenic options.

Herbicide resistant crops have only enabled the use of herbicides on crops that would not otherwise have the natural selectivity to allow their use, such as glyphosate on glyphosate tolerant crops. This has resulted in a shift in the herbicide active ingredients used on these crops, but has not eliminated or reduced (on an acreage basis) the use of herbicides. The use of transgenic resistant crops for herbicide modes-of-action other than glyphosate has been more limited to date. However, it is likely that opportunities for new herbicide modes-of-action and accompanying resistance transgenes will be developed in the future as the technology continues to mature. Some of the benefits of doing so include enabling commercialization of new herbicide modes-of-action to manage weed shifts and resistant weeds, introducing reduced rate herbicides, and developing herbicides with improved environmental and toxicology profiles.

Transgenic disease resistance is mainly still in the experimental stage with only a few limited applications in the marketplace such as virus resistant papaya. However, many public and private institutions are actively pursuing transgenic disease resistance research with the expectation of producing commercially valuable solutions in the future. Fungicide use will likely be reduced just as with insecticides when disease resistant genes are introduced. However, fungicides will also still be needed to provide resistance management options, to improve the spectrum of disease control, and to provide disease control in small markets as with insecticides.

SURVEY OF HERBICIDE-RESISTANT WEEDS IN MICHIGAN CHRISTMAS TREE PLANTATIONS. Steven A. Gower, Robert J. Richardson, and Bernard H. Zandstra, Academic Specialist, Diagnostic Services, Research Associate and Professor, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Michigan is one of the largest producers of Christmas trees in the country, ranked in the top three in trees harvested and acres in production. Christmas tree growers use herbicides as part of an effective and economical weed management program. A few herbicides have been used extensively and exclusively for weed control in Michigan. Growers are concerned with the possibility of weed shifts and herbicide resistance.

In response, a survey has been initiated in Michigan Christmas tree plantations to (1) identify and document weeds species in the top five-producing counties, (2) collect mature seeds from these weeds, and (3) determine whether these species are resistant to several common Christmas tree herbicides.

To date, several independent greenhouse experiments have been conducted to evaluate herbicide resistance in common ragweed, horseweed, and velvetleaf. Herbicides used in these experiments include atrazine, chlorimuron, cloransulam-methyl, glyphosate, imazamox, oxyfluorfen, and simazine. Known susceptible control populations were included with each experiment.

Common ragweed plants survived foliar-applied cloransulam-methyl and imazamox at 35 and 88 g ai ha^{-1}, respectively. Horseweed plants survived soil-applied simazine at 4.4 and 13 kg ai ha^{-1} and foliar-applied atrazine at 2.2 and 6.7 kg ai ha^{-1}. Additional horseweed populations survived foliar-applied atrazine at 6.7 kg ai ha^{-1}, chlorimuron at 18 g ai ha^{-1}, and cloransulam-methyl at 35 g ai ha^{-1}. At least one horseweed population demonstrated resistance to both triazine and acetolactate synthase (ALS)-inhibiting herbicides, which to our knowledge would be the first report in the United States. Results from experiments to date indicate ALS resistance in one common ragweed population, triazine resistance in four populations, and triazine and ALS resistance in at least one horseweed population collected from Michigan Christmas tree plantations.

TEST RESULTS IN EASTERN CHRISTMAS TREES WITH A NEW BLEND PRODUCT OF SULFOMETURON-METHYL AND HEXAZINONE. Marsha J. Martin, Susan K. Rick, Donald D. Ganske, Mick F. Holm and Ronnie G. Turner, Field Development, DuPont Crop Protection, E. I. DuPont De Nemours and Co.,Wilmington, DE 19898.

A new water-dispersible, granular blend of 6.5% sulfometuron-methyl and 68.6% hexazinone (Westar ™) is labeled for weed control in non-crop sites and for the control of grass and broadleaf weeds in conifers grown for foresty. In 2004, Westar™ herbicide was labeled in Oregon and Washington for weed control in Christmas tree plantings at rates of 1.25 to 1.5 pounds per acre. In 2004, six trials were initiated to test crop safety and weed control spectrum of Westar™ herbicide in Christmas trees in the Eastern US.

The six trials were located in CT, MI, NY, PA (2) and WI and included several Chritmas tree species such as Fraser Fir, Blue Spruce and Douglas Fir. Rates of Westar™ herbicide tested ranged from 12 to 40 ounces of product. Application timing was targeted in the spring before bud break either preemergence or postemergence to the weeds.

Westar™ herbicide gave excellent control of several weed species including quackgrass, large crabgrass, yellow foxtail, giant foxtail, Buckhorn plantain, Broadleaf plantain, field violet, common dandelion, mouseear chickweed, and common ragweed. At rates up to 20 ounces/acre, crop response was minimal on Fraser Fir and Douglas Fir, with no crop response on Blue Spruce.

Future testing in Christmas trees will examine a ratio containing lower rates of sulfometuron-methyl relative to hexazinone.

FRASER FIR AND WEED RESPONSES TO HEXAZINONE AND SULFOMETURON.
Robert J. Richardson, Bernard H. Zandstra, Jill O'Donnell, and Norm Myers, Research Associate, Professor, District Extension Agent, and County Extension Director, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Field studies were conducted in 2003 and 2004 to determine Fraser fir and weed responses to applications of hexazinone and sulfometuron. The first study, conducted in 2003 and 2004, consisted of hexazinone applied at 0.25, 0.5, 0.75, and 1 lb ai/A and sulfometuron at 0.035, 0.07, 0.105, and 0.14 lb ai/A. Comparison treatments of flumioxazin (0.25 lb ai/A) and an untreated control were also included. A second study was conducted in 2004 to evaluate mixtures of hexazinone plus sulfometuron. Treatments included hexazinone plus sulfometuron at 0.5 lb/A plus 0.04 lb/A, 0.7 lb/A plus 0.065 lb/A, 0.85 lb/A plus 0.08 lb/A, and 1.7 lb/A plus 0.16 lb/A, respectively, and comparison treatments of simazine (2 lb ai/A) plus pendimethalin (3 lb ai/A) plus glyphosate (0.75 lb ae/A), flumioxazin plus glyphosate, and an untreated control. Treatments were applied on April 15, 2003, and May 3, 2004, before bud-break to established Fraser fir measuring 3 to 4 ft in height. In study 1, Fraser fir injury was 2 to 14% during the growing season with sulfometuron, but did not exceed 2% with hexazinone or flumioxazin treatments. At 4 months after treatment (MAT) quackgrass control exceeded 74% with all hexazinone or sulfometuron treatments, but was 50% with flumioxazin. Horseweed was controlled 78 to 93% with hexazinone, but control did not exceed 63% with other treatments. Common ragweed was controlled 83 to 100% with hexazinone and flumioxazin treatments, but only 40 to 68% with sulfometuron. In study 2, Fraser fir injury ranged 3 to 16% during the growing season with mixtures of hexazinone plus sulfometuron, but injury with comparison treatments did not exceed 2%. Leader growth corresponded to injury and was shorter with all hexazinone plus sulfometuron treatments than the untreated control. At 4 MAT, quackgrass control was 93 to 98% with all hexazinone plus sulfometuron treatments and 77% with either comparison treatment. Control of common ragweed and horseweed with hexazinone plus sulfometuron was generally rate responsive at 58 to 97%; control of the two weeds with the comparison treatments was 50 to 73%. Common milkweed was not controlled in either study.

LEAF ABNORMALITIES ON WHITE OAKS MAY BE LINKED TO DRIFT OF CHLOROACETAMIDE HERBICIDES. Jayesh B. Samtani, John B. Masiunas, and James E. Appleby, Graduate Research Assistant and Associate Professors, Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana-Champaign, Urbana, IL 61801.

In some years, the emerging leaves of white oak trees in the Midwest develop abnormally, without interveinal tissues. This abnormality is referred to as tatters. Reports to State Foresters and Extension Specialists associated tatters with herbicide applications. The objective of our study was to determine if herbicide drift could cause tatters. Potted white oak seedlings 0.6 m in height were treated with 2,4-D (2-ethylhexyl ester), 2,4-D (2-ethylhexyl ester) + glyphosate, acetochlor + atrazine, dicamba, glyphosate and metolachlor at 1/4, 1/10 and 1/100 X of the standard field use rate. The seedlings were treated at three growth stages i) swollen bud, ii) leaves unfolding, and iii) expanded leaves. A compressed air spraying chamber with a moving 80015 EVS spray nozzle was used to apply the herbicides. Tatters were observed on 62 % of total white oaks treated with acetochlor + atrazine and 38 % of total white oaks treated with metolachlor when treated at the leaf unfolding stage. Leaf tatters did not occur on seedlings treated with acetochlor + atrazine or metolachlor at the other two growth stages, or on seedlings treated with other herbicides or the controls. A month and half after treatment with acetochlor + atrazine or metolachlor, oak seedlings produced a new flush of leaves which were unaffected by leaf tatters. The study indicates that tatters on white oaks, may be linked to drift of chloroacetamide herbicides when leaves are unfolding. The study will be repeated in 2005.

PRODIAMINE APPLICATION TIMING FOR LARGE CRABGRASS AND JAPANESE STILTGRASS CONTROL. Jeffrey F. Derr, Professor, Virginia Tech, Hampton Roads Agricultural Research and Extension Center, 1444 Diamond Springs Road, Virginia Beach, VA 23455.

Large crabgrass is a common and troublesome summer annual weed in turf. Japanese stiltgrass [*Microstegium vimineum* (Trin.) A. Camus] is a summer annual grass that has aggressively invaded shaded areas in turf, ornamentals, and noncrop areas in Virginia and other mid-Atlantic states. Experiments were conducted in 2003 and 2004 to determine the onset of germination for Japanese stiltgrass and evaluate herbicide application timing for control of this invasive species. The effectiveness of prodiamine applied in winter or early spring for Japanese stiltgrass control was compared to that seen with large crabgrass. Winter applications of prodiamine have utility for large crabgrass control due to its longevity in soil and may also be useful for control of Japanese stiltgrass.

All experiments utilized a randomized complete block design with 4 replications. Japanese stiltgrass and large crabgrass plants were transplanted in summer of 2002 and 2003 and allowed to set seed in bare ground plots for the germination trials. Seedling counts were taken were taken daily, starting with the first indication of emergence the following March.

An established stand of ‘Shenandoah’ tall fescue was used for the large crabgrass control trials. A wooded site was used for the Japanese stiltgrass control experiments. Prodiamine was applied once in December or March at 0.84 kg ai/ha, twice at 0.42 kg ai/ha in December plus March, December plus May, or March plus May, or three times at 0.42 kg ai/ha in December plus March plus May. March applications were made prior to the germination of either weed species.

Japanese stiltgrass emergence was first observed on March 14 in 2003 and March 19 in 2004. Large crabgrass first emerged on March 21 in 2003 and April 15 in 2004.

Numerically highest control of large crabgrass occurred in plots treated in December plus March plus May, with 95% control seen in July of 2003 and 99% control in July of 2004. Prodiamine applied once at 0.84 kg/ha in December controlled large crabgrass 75% and 84%, respectively in 2003 and 2004. Prodiamine applied once at 0.84 kg/ha in March controlled large crabgrass 65% in 2003 and 79% in 2004. All multiple application treatments of prodiamine controlled large crabgrass 80% or higher in both years when evaluated in July.

All prodiamine treatments significantly reduced Japanese stiltgrass stand when evaluated in late April of each year. However, no treatment provided acceptable control of Japanese stiltgrass when evaluated in July of 2004. Three applications of prodiamine controlled Japanese stiltgrass 83% in May of 2003 but only 60% in May of 2004. Three applications of prodiamine reduced large crabgrass ground cover in August by 92% in 2003 and 96% in 2004. This treatment reduced Japanese stiltgrass ground cover in August by 82% in 2003 but only 44% in 2004. The lower control of Japanese stiltgrass is primarily due to the growth of tillers during the summer, allowing the species to fill in bare areas between plants. There was little competing vegetation in the wooded site. The higher organic matter content in the Japanese stiltgrass site may have caused greater adsorption of prodiamine, resulting in lower control of this species compared to large crabgrass.

Japanese stiltgrass germinates earlier in spring than large crabgrass. Winter applications of prodiamine provide acceptable large crabgrass control the following July. Multiple applications provide improved large crabgrass control. Prodiamine applied in winter or early spring reduces stand of Japanese stiltgrass but does not provide as high a level of control compared to that seen in large crabgrass.

QUACKGRASS CONTROL IN KENTUCKY BLUEGRASS. Kirk A. Howatt and Deying Li, Assistant Professor and Assistant Professor, North Dakota State University, Fargo, ND 58105-5051.

Kentucky bluegrass turf often is invaded by quackgrass in cool climates because quackgrass rhizomes can push through the sod and establish new colonies. Some cultural practices can help prevent quackgrass invasion, but no herbicide currently is registered for selective removal of quackgrass from Kentucky bluegrass. An experiment was established to evaluate the response of quackgrass and Kentucky bluegrass to four herbicides. Studies were established in the fall at two locations in North Dakota. Treatments included fall or spring application of flucarbazone at 30 g ha^{-1}, primisulfuron at 40 g ha^{-1}, MKH 6561 at 35 g ha^{-1}, and sulfosulfuron at 35 g ha^{-1}. In addition, these four herbicides were applied in the spring as split-application treatments in two equal applications so that the total amount of each herbicide per area remained constant. Quackgrass showed injury with all herbicides applied in the fall. Sulfosulfuron or MKH 6561 resulted in more injury to quackgrass than flucarbazone or primisulfuron, but control was less than 60% 4 wk after application. Fall-applied herbicide treatments provided partial quackgrass control the following spring, but spring application of herbicides resulted in as much as 95% quackgrass control during the growing season compared with 79% control from fall application. Split application of herbicides in the spring provided similar or greater control than single application. Split application of MKH 6561 still provided 83% quackgrass control at the end of the season. Kentucky bluegrass injury primarily was manifested as stunting, although plots treated with primisulfuron also exhibited chlorosis following application and again at the end of the season when the summer drought was relieved and moisture became available. Turf color and quality did not differ among treatments.

EFFECT OF DRIFT-REDUCING NOZZLES ON HERBICIDE EFFICACY IN SUGARBEET (*BETA VULGARIS* L.). Kevin R. Jacobson and Alan G. Dexter, Graduate Research Assistant, Plant Sciences Department, North Dakota State University, Fargo, ND 58105 and Professor, Plant Sciences Department, North Dakota State University and University of Minnesota, Fargo, ND 58105.

Field experiments were conducted to determine the influence of nozzle type and travel speed on herbicide efficacy. Venturi and pre-orifice type nozzles were compared to the standard Spraying Systems XR TeeJet fan nozzle (XR). Venturi nozzles were Spraying Systems AI TeeJeet and Greenleaf Technologies Air Mix (AM). Pre-orifice nozzles were Spraying Systems Turbo TeeJet (TT), Wilger Industries Combo-Jet DR (DR), and Hypro Corp Ultra Low Drift (ULD). Desmedipham and phenmedipham at 90 g/ha plus triflusulfuron at 4.5 g/ha plus clopyralid at 34 g/ha plus clethodim at 34 g/ha plus methylated seed oil adjuvant at 1.5% v/v was the postemergence micro-rate treatment applied two times at a seven-day interval. The postemergence micro-rate was applied to sugarbeet, durum wheat, oat, foxtail millet, corn, flax, canola, amaranth, and flax using all nozzle types at two travel speeds. Increasing travel speed from 4.8 km/h to 7.2 km/h reduced amaranth and flax control with all nozzle types using either 7.6 L/min or 15.1 L/min nozzle size. The 15.1 L/min nozzle size gave less control compared to 7.6 L/min nozzles at the 7.2 km/h travel speed for all nozzles types. ULD and AI were less effective than the standard XR in control of flax and canola. DR, AM, and TT nozzles were as effective as XR in control of all species studied.

SPRAY PARTICLE SIZE AND DISTRIBUTION WITH VARIOUS NOZZLE TIPS, PRESSURES, HERBICIDES AND ADDITIVES. Robert N. Klein, Jeffrey A. Golus and Susan L. Horne, Professor, Research Technologist and Student, University of Nebraska, North Platte, NE 69101.

In 1987 the British Crop Protection Council adopted the spray droplet classification primarily to enhance efficacy. They use the term Spray Quality for droplet size categories. In 2000, the American Society of Agricultural Engineers Pest Control and Fertilizer Committee developed ASAE S572, Spray Nozzle Classification by Droplet Spectra, primarily to control spray drift. This standard defines spectrum categories for the classification of spray nozzles, relative to specified reference fan nozzles discharging spray into static air, or so that no stream of air enhances atomization. The droplet spectra produced by single elliptical orifice reference nozzles with specified liquid mixture, flow rates, operating pressures and spray angles, are specified by the standard to establish the threshold of division between nozzle classification categories. Generally the standard is based on spraying water through the reference nozzles and the nozzles to be classified. However, spray solution properties may affect droplet sizes. Most classifications of nozzles have been done with just water.

Research has been conducted with a Sympatec Helos KF Analyzer. The system uses laser diffraction to determine particle size. With the R6 lens, it can determine particle sizes in a range from 0.5 to 1770 microns. A study was done to determine the particle size distribution of glyphosate and ammonium sulfate with and without different adjuvants. Spraying Systems Extended Range, Turbo TeeJet, Turbo Flood and Air Induction nozzles were used. Both the herbicide and adjuvants affected particle size. Some nozzles are affected more than others, and would result in the nozzle receiving a different droplet spectra classification.

THE AFFECT OF PULSE WIDTH MODULATION NOZZLE CONTROL ON GLYPHOSATE AND PARAQUAT EFFICACY. Robert E. Wolf and Dallas E. Peterson, Extension Specialist, Biological and Agricultural Engineering, and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

This study was designed to measure herbicide efficacy using Pulse Width Modulation (PWM) and a common flat-fan style nozzle. The PWM system utilizes a computer controlled modulation valve to manage application volume independent of droplet size and pressure. The experiment included comparisons of three different orifice sizes of the turbo flat-fan (TT) at two operating pressures, 173 and 345 kPa. All treatments were conducted at 8 km/h and at a spray volume of 94 L/ha. The nozzle angle and orifice sizes used were 11002, 11004, and 11006. The applications were made with a tractor-mounted 3-point sprayer equipped with a 6-nozzle PWM boom. Nozzles were spaced at 51 cm and located 51 cm above the target. Glyphosate at 0.42 kg ae/ha and paraquat at 0.63 kg ai/ha were used to compare efficacy on common velvetleaf, sorghum and corn. Sublethal herbicide rates were used to accentuate efficacy differences. The experiment had a randomized complete block design in a split plot arrangement with herbicide as the main plot and spray tip by pressure as the subplot. Efficacy ratings for 27 days after treatment (DAT) are reported. Droplet size characteristics are given for each treatment based on Spraying Systems charts which reflect ASAE Standard S-572 - *Spray Nozzle Classification by Droplet Spectra*. The TT 11002 was classified as a coarse droplet at 173 kPa and a medium droplet at 345 kPa. Both the 11004 and 11006 were classified as very coarse and coarse at the same pressures respectively.

Efficacy ratings show that significant differences and interactions were found among herbicide, nozzle, and pressure variables. At 27 DAT species control varied between glyphosate and paraquat as would be expected. Glyphosate provided better control for all three species with significant differences measured for sorghum and corn. A significant interaction was measured for nozzle, pressure, and chemical in sorghum. In general, the 11004 orifice had better control when compared to the 11002 and 11006 orifices. The differences were more pronounced with paraquat than glyphosate.

Significant differences in control occurred among orifice size and pressure comparisons for all species. For both corn and sorghum, the better control occurred at the higher pressure through all three orifice sizes. Differences were greater for the 11002 and were less for the larger orifice 11006. For velvetleaf, the 11002 was significantly better for control at the higher pressure. That was reversed for the 11004 and 11006, but the differences were not significant.

As evidenced in this study, several significant differences were found among treatments. The main finding and trend was that the percent control was better for the higher pressure treatments at the smaller orifice size. This trend was not found with velvetleaf. There was also a significant difference in performance between glyphosate and paraquat for sorghum and corn with glyphosate having better control. That significance was not present for velvetleaf. The tip, pressure, and chemical interaction is also significant for sorghum with glyphosate again showing better control when compared to paraquat and slightly better for control at the higher pressure. The pressure differences were more pronounced with paraquat with higher pressure significantly different in all comparisons.

When the nozzle and pressure treatments are assigned a classification based on ASAE S-572, except for two treatments with velvetleaf, all smaller droplet categories had better control.

HUMECTANTS AS ADJUVANTS WITH GRASS-CONTROL HERBICIDES. Jamie D. Kloster and Calvin G. Messersmith, Graduate Research Fellow and Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Plants under hot, dry conditions prior to and during herbicide application have an increased tolerance to several herbicides when compared to unstressed plants. A humectant is a hygroscopic substance that increases the equilibrium water content of a spray droplet, thus increasing the amount of time it takes a droplet to dry. Research was conducted in the greenhouse and growth chamber to determine the effect of selected humectants on efficacy of clethodim, imazamethabenz, nicosulfuron, and sethoxydim on plants subjected to hot, dry conditions. The humectants evaluated were ammonium nitrate, ethylene glycol, polyethylene glycol (8000), and TCA, each at five rates from 0.125 to 2.0% w/w. Each herbicide plus a methylated seed oil, with and without a humectant, was applied to oat at the three-leaf stage. Ammonium nitrate slightly increased sethoxydim efficacy. Ethylene glycol tended to enhance nicosulfuron efficacy but reduced imazamethabenz and sethyoxydim efficacy. Polyethylene glycol tended to increase imazamethabenz efficacy at polyethylene glycol rates less than 1.0% w/w but decreased imazamethabenz efficacy at higher polyethylene glycol rates. Clethodim efficacy was enhanced at polyethylene glycol rates less than 0.5% but was decreased at polyethylene glycol rates greater than 0.5%. Nicosulfuron efficacy increased across all polyethylene glycol rates. TCA tended to reduce imazamethabenz and nicosulfuron efficacy. Polyethylene glycol and TCA in gravimetric watchglass experiments resulted in less water loss than water alone after 12 and 24 h. While reduction in water lost was not different for ammonium nitrate and ethylene glycol compared to water, watchglasses with these treatments visibly retained water for a longer period than water alone.

THE EFFECT OF NOZZLE TYPE IN COMBINATION WITH ELECTROSTATICS ON GLYPHOSATE AND PARAQUAT EFFICACY. Robert E. Wolf and Dallas E. Peterson, Extension Specialist, Biological and Agricultural Engineering, and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

This study was designed to measure herbicide efficacy and droplet characteristics using the Energized Spray Process (ESP) and three common flat-fan spray nozzles. The ESP system utilizes contact charging of the spray liquid prior to atomization at the nozzles. The charge creates a high-intensity electrostatic field between the nozzle and plant. The experiment included comparisons of the extended range (XR), turbo (TT), and venturi (AI) flat-fans with and without the electrostatic charge. All treatments were conducted at 207 kPa, 16 km/h, and at a spray volume of 47 L/ha. The nozzle angle and orifice size used in all treatments was 11002. The applications were made with a Spra-Coupe 3640 equipped with an ESP boom spanning 18.6m. Nozzles were spaced at 51 cm and located 51 cm above the target. The three nozzle types were evenly split in groups across the boom (left 1/3 were XR, middle 1/3 were TT, and right 1/3 were AI) for all treatments. Glyphosate at 0.31 kg ae/ha and paraquat at 0.0.63 kg ai/ha were used to compare efficacy on common sunflower, sorghum and corn. Sublethal herbicide rates were used to accentuate any efficacy differences. The study had a randomized complete block design in a split-split plot arrangement with herbicide as the main plot, electrical charge as the subplot, and spray tip as the sub-subplot. In addition to efficacy ratings at 7, 14, and 21 days after treatment (DAT), kromekote papers were placed under the spray boom to collect droplet spectra data. Five kromekote papers per treatment over one replication were summarized. DropletScan software was used to analyze the papers.

Efficacy ratings at 21 DAT show that very few significant differences were found among herbicide, nozzle, and electrostatic charge variables. No significant differences in control occurred among the interaction of nozzle, chemical, and electrostatic charge for all three species. Only minor differences in control occurred among spray nozzles. The AI tip showed the best control with glyphosate for all species. The XR had nearly the same control as the AI with the TT somewhat less. With paraquat, the TT was slightly better followed by the AI and the XR was lowest. However, in all cases the differences were small and not significant.

Significant differences in control were shown with the electrostatic charge and chemical interaction on corn at 21 DAT. For both glyphosate and paraquat the control was higher without the electric charge, although the difference was significant for glyphosate, but not for paraquat.. Control was significantly higher without electrical charge than with charge for all three species at both 14 and 21 DAT, (except for cosf at 14 DAT).

The droplet statistic volume median diameter (VMD) averaged across all treatments show differences as expected for nozzle types with the XR at 303 microns, TT at 363 microns, and AI at 543 microns. When classified according to the ASAE S-572, the XR and TT are medium sized drops and the AI drops are very coarse. Percent area coverage exhibited very little differences among the three nozzle types (XR=8.7%, TT=8.0%, and AI=8.8%).

As evidenced in this study, very few significant differences were found among treatments. The main finding and trend was that the percent control was better without the electrostatic charge with significant differences reported for all three species at 21 DAT. It was also interesting to note that the AI nozzle performed well in percent control compared to the other nozzle types and the XR and TT had less control than might have been expected. Even though the droplet spectra were different for each the percent area coverage for each was nearly the same.

EFFICACY OF GLYPHOSATE WITH VARIOUS SPRAY PARTICLE SIZES FROM AIR INDUCTION, EXTENDED RANGE, TURBO FLOOD AND TURBO TEEJET NOZZLE TIPS.

Robert N. Klein, Stevan Knezevic, Robert G. Wilson, Alex R. Martin, Fred W. Roeth, and Brady F. Kappler, Professors and Extension Educator, University of Nebraska, Lincoln, NE 68583.

Field research was conducted at several sites across Nebraska in 2004 to determine the effect of varying particle sizes on the efficacy of glyphosate. The glyphosate used for all purposes was Roundup WeatherMax. The trial was conducted at Scottsbluff, North Platte, Concord, Clay Center and Lincoln. The nozzles and pressures were chosen based on the particle size distribution obtained from each using a Sympatec Helos particle analyzer. The analyzer uses laser diffraction to determine particle size and distribution. Nozzles are classified into categories Very Fine, Fine, Medium, Coarse, Very Coarse and Extremely Coarse based on droplet size. The nozzles used in the study and their classification were: XRC11003 at 35 psi - Fine; XRC11004 at 20 psi – Medium; TT11003 at 35 psi – Coarse; TF2 at 20 psi – Very Coarse, AIC110025 at 50 psi – Very Coarse. The nozzles all delivered 0.28 gallons per minute at the given pressures. The volume median diameter in microns and percent of spray volume less than 210 microns determined by the analyzer are as follows: XRC11003 at 35 psi with water, 0.19 lb ae/a glyphosate + 2% AMS, 0.39 lb ae/a + 2% AMS, 0.77 lb ae/a + 2% AMS = 237-41, 217-48, 206-51, 201-53; XRC11004 at 20 psi with water, 0.19 lb ae/a glyphosate + 2% AMS, 0.39 lb ae/a + 2% AMS, 0.77 lb ae/a + 2% AMS = 327-22, 293-29, 285-31, 289-31; TT11003 at 35 psi with water, 0.19 lb ae/a glyphosate + 2% AMS, 0.39 lb ae/a + 2% AMS, 0.77 lb ae/a + 2% AMS = 400-16, 381-18, 367-19, 346-22; TF2 at 20 psi with water, 0.19 lb ae/a glyphosate + 2% AMS, 0.39 lb ae/a + 2% AMS, 0.77 lb ae/a + 2% AMS = 574-7, 578-7, 536-9, 472-13; AIC11025 at 50 psi with water, 0.19 lb ae/a glyphosate + 2% AMS, 0.39 lb ae/a + 2% AMS, 0.77 lb ae/a + 2% AMS = 571-6, 536-5, 498-7, 404-20.

Three glyphosate rates were used for the field efficacy trials were: 0.58 lb ae/a, 0.29 lb ae/a, and 0.145 lb ae/a. Ammonium sulfate at 2% w:w was included in each treatment, and treatments were applied at 10 gpa. Weeds were planted at each site to obtain a uniform stand. Weeds planted were: field corn, common oil sunflower, ivyleaf morningglory, common lambsquarters and velvetleaf. Over all the weeds, locations and glyphosate rates, only small differences in efficacy were observed. Therefore, one should make nozzle tip selection when applying glyphosate and ammonium sulfate based on particle size that is least prone to drift.

SOME BIOLOGICAL CHARACTERISTICS THAT FOSTER THE INVASION OF *PROSOPIS JULIFLORA* (SW.) DC. AT MIDDLE AWASH RIFT VALLEY AREA, NORTH-EASTERN ETHIOPIA.

Hailu Shiferaw [a] *, Dr. Demel Teketay[b], Dr. Sileshi Nemomissa[c], and Dr. Fassil Assefa[c]

A study on some biological features of *Prosopis juliflora*, a multipurpose leguminous species introduced to Ethiopia, was carried out at Melka-Worer, North-east Ethiopia. The study focused on the number of seeds produced in a pod during the study period, seed dispersal through droppings of animals, soil seed banks, seed germination and stumping height of trees and coppicing ability of *P. juliflora*. The overall mean number of seeds was 2374 seeds/pod. The mean weight of a seed of Prosopis was 0.0275 g 70.001 (S.E.) while there were 36,000–37,000 seeds/kg. The number of seeds recovered from 1 kg of droppings of each animal ranged between 760 (goats) and 2833 (cattle). The total mean soil seed density, in the litter layer and down to 9 cm depth, was 1932 seeds/m2 (±307 S.E.). The highest germination percentage was obtained from seeds that were treated with mechanical scarification (100%) and sulfuric acid for 15–60 min (97–99%). About 37% and 47% of the seeds recovered from droppings of goats and warthogs, respectively, germinated. All stumped trees of *P. juliflora* produced coppices except those stumped at 10 cm below ground. The results clearly demonstrated that *Prosopis* is equipped with a number of biological characteristics that foster its rapid invasion of new areas. These include: (i) production of many, small and hard seeds capable of surviving passage through the digestive system of animals, entering into the soil to form soil seed banks and remaining viable until favorable conditions for germination and seedling establishment appear; (ii) attractive and rewarding pods for animals, containing fleshy and sweet mesocarp embodying the numerous small seeds, which is sought after by both domestic and wild animals, meant for long-distance dispersal; (iii) accumulation of dormant but long-lived viable seed reserves that would serve as sources of regeneration of new *Prosopis* plants in the event of disturbance that might eliminate the aboveground stands; (iv) production of a mixture of seeds, with a few capable of germinating immediately after dispersal to exploit the favorable conditions that might exist at the time of dispersal, while the majority remain dormant for spreading germination over time and space; and (v) great ability of resprouting and fast coppice growth from stumped/damaged trees, making it a very strong competitive invader combined with its sexual reproduction. Combinations of all these characteristics make *Prosopis* a powerful noxious invader as can be evidenced from its rampant invasion in the study site and elsewhere in the tropics. Therefore, any effort in the management, control or elimination of *Prosopis,* which does not take these biological characteristics is bound to fail.

PRIMARY SEED DORMANCY IN AMBROSIA TRIFIDA L. (GIANT RAGWEED). Brian J. Schutte, Emilie E. Regnier, and S. Kent Harrison, Graduate Research Associate, Associate Professor and Professor, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210

Giant ragweed is a summer annual that interferes with the production of summer annual crops. Year-to-year persistence of giant ragweed populations requires a period of seed dormancy immediately following autumn seed dispersal, yet little is known about primary seed dormancy of giant ragweed. Giant ragweed dispersal units are embryos encapsulated by a series of covering structures including a membranous layer, pericarp and involucre. In general, seed dormancy can be attributed to an inhibitory mechanism within the embryo (embryo dormancy) or constraints on the embryo imposed by the embryo-covering structures (coat-imposed dormancy).

We monitored the progress of putative embryo- and coat-imposed dormancy loss for giant ragweed dispersal units in natural winter conditions. Dispersal units were buried, regularly retrieved and dissected to produce embryos, and embryos with covering structures for germination assays at 20°C under 12 hr photoperiods. Proportions that failed to germinate (lack of visible radicle protrusion) indicated dormancy intensities and comparisons between isolated and covered embryos provided measures of coat-imposed dormancy. Results showed that winter-induced removal of giant ragweed seed dormancy involves a sequential reduction of embryo dormancy and coat-imposed dormancy. This suggests that the final barrier to radicle protrusion is the interaction between a non-dormant embryo and an inhibitory set of covering structures.

We also determined the effects of three environmental conditions on seed dormancy with a laboratory 2x2x2 factorial experiment. First, seeds were treated for up to 273 days with two thermal environments (4°C, 20°C) and two hydric environments (free water available, free water absent). Following thermal and hydric treatments, seeds were subjected to germination assays of two light environments (illuminated, dark). Seed dormancy was reduced most rapidly by moist, cold (4°C) conditions followed by illuminated germination assays (72% dormancy reduction attained at a rate of 0.82% reduction per day at 4°C). Seed dormancy was reduced by moist, cold (4°C) conditions followed by germination assays in darkness (54% dormancy reduction attained at a rate of 0.57% reduction per day at 4°C). Dormancy was slowly reduced in dry, cold (4°C) conditions followed by illuminated germination assays (7% dormancy loss attained at a rate of 0.02% reduction per day at 4°C). These results indicate giant ragweed seed dormancy reduction has a near absolute requirement for cold conditions. The promotional effect of light was not expected since light requirements are not common for large-seeded species like giant ragweed. Light requirements affect seed performance in the field and therefore, additional research into the giant ragweed light requirement for termination of primary seed dormancy is warranted.

SECONDARY SEED DISPERSAL BY THE EARTHWORM, *Lumbricus terrestris*.
Emilie E. Regnier, S. Kent Harrison, and Jerron T. Schmoll, Associate Professor, Professor, and Research Associate, The Ohio State University, Columbus, OH 43210.

Field experiments and surveys were conducted to determine the importance of the earthworm, *Lumbricus terrestris* (common nightcrawler), in the movement of seeds from the soil surface into the seedbank. *Lumbricus terrestris* lives in permanent vertical burrows and forages at the soil surface for organic matter such as leaves, twigs and seeds, which it drags inside its burrow for later feeding as the plant tissues decompose. In a foraging preference study, *L. terrestris* collected seeds of six large-seeded weed and crop species, but preferred giant ragweed, common sunflower, and burcucumber. We monitored *L. terrestris* seed gathering activity under conditions of natural seed dispersal in a fallowed crop field with an established, dominant stand of giant ragweed and a natural *L. terrestris* population. *Lumbricus terrestris* collected and cached over 60% of the giant ragweed seed rain in its burrows. The subsequent spring, over 60% of all giant ragweed seedlings emerged from *L. terrestris* burrows in the same field, indicating that many of the cached seeds retain their viability within the burrows. A survey of giant ragweed populations at two other sites showed a similar distribution of giant ragweed plants emerging from *L. terrestris* burrows. Studies with seeds to which threads were glued showed that *L. terrestris* buried most giant ragweed seeds in the upper 10 cm of the soil profile, which is within emergence limits for this species. Field experiments in which access to giant ragweed seeds was manipulated to allow or exclude *L. terrestris* and seed predators (i.e., mice) showed that giant ragweed seed predation was reduced when *L. terrestris* was present compared to when it was excluded, probably due to seed burial by *L. terrestris*. Collectively, these data provide evidence that *L. terrestris* forages selectively for seeds and can exert a strong influence on the secondary dispersal of large weed seeds, potentially decreasing their vulnerability to predation, increasing seed bank formation and seedling recruitment.

DEFINING THE ENVIRONMENTAL REQUIREMENTS OF A CANDIDATE BIOHERBICIDE FOR COMMON WATERHEMP. David A. Smith, David A. Doll[1], Daljit Singh* and Steven G. Hallett, Department of Botany& Plant Pathology, Purdue University, West Lafayette, IN. [1] Department of Plant Pathology, University of California, Davis, Davis, CA 95616, USA

Common waterhemp has emerged as a key weed in midwestern cropping systems in recent years. Delayed and prolonged periods of emergence and resistance to some herbicides may have contributed to the widespread distribution of the species. *Microsphaeropsis amaranthi,* currently under investigation as a bioherbicide for common waterhemp, is a virulent pathogen with a host range restricted to the Amaranthaceae. Environmental factors were investigated to identify the optimum and limiting conditions affecting the virulence and weed control efficacy of *M. amaranthi* on common waterhemp. Conidial germination was greatest at approximately 20 ^{o}C, and hyphal growth was greatest at approximately 25 ^{o}C. Disease expression was greatest when inoculated plants were incubated with a leaf wetness period of 18 h at 18-23 ^{o}C. In a field experiment, common waterhemp seedlings (4-6 leaves) were sprayed with *M. amaranthi* conidia (3 x 10 ^{6} conidia /ml) every week from April 15 to August 12, 2004. Significant disease severity was observed when prevailing weather conditions presented a leaf wetness period of at least 10 h at temperatures of approximately 16-24 ^{o}C. These conditions occurred on seven separate occasions. In contrast, on eleven occasions no disease was found. The study shows that there is potential of *M. amaranthi* to be used as bioherbicide, but environmental constraints may play a major role in its effectiveness. Future research will focus on methodologies for the enhancement of activity of *M. amaranth*i under field conditions.

GROWTH ANALYSIS OF LONGSPINE SANDBUR. Leandro D. Perugini, Phillip W. Stahlman, and J. Anita Dille, Graduate Research Assistant, Department of Agronomy, Kansas State University, Manhattan, KS 66502, Professor, Kansas State University Agricultural Research Center, Hays, KS 67601, and Assistant Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66502.

A greenhouse experiment was conducted to evaluate the effect of shade on the growth and development of longspine sandbur. Three treatments consisted of no shade [382 µmol m^{-2} s^{-1} photosynthetic photon flux density (PPFD)], continuous 65% shade (134 µmol m^{-2} s^{-1} PPFD), and no shade for 16 days after emergence (DAE) until three tillers were present followed by continuous 65% shade. Plants were harvested at 18, 35, 50, and 62 DAE. The effect of shade was greater for dry weight than for leaf area. At 62 DAE, individual plant dry weight and leaf area decreased 70 and 24%, respectively, for plants subjected to delayed shading compared to 89 and 62% reductions, respectively, for plants subjected to continuous shading, all compared to plants growing with no shade. Plant dry weight and leaf area were subjected to natural logarithm transformations and used to calculate several growth parameters. Shade and its duration markedly increased the leaf area ratio (LAR), leaf weight ratio (LWR), and specific leaf area (SLA) of plants over time compared to no shade. Increased LAR, product of LWR and SLA, of longspine sandbur plants with shading was due mainly to increased SLA, a measure of surface area per unit leaf dry weight typical shading response. Conversely, shading decreased net assimilation rate (NAR). The increase in LAR in response to shading suggests longspine sandbur increased distribution of new biomass to leaves more than stem. Thinner leaves, lower leaf area, and dry weight results confirm that longspine sandbur is a weed species highly susceptible to shading.

MORPHOLOGICAL VARIATION OF COMMON LAMBSQUARTERS AND GIANT FOXTAIL ASSOCIATED WITH 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.

Plants use an array of physiological mechanisms to sense resource availability; such mechanisms may trigger adjustments in biomass allocation patterns to maximize access to key limiting resources, thus increasing competitive ability. Numerous studies conducted in controlled environments have demonstrated altered biomass allocation patterns in response to decreased red/far-red (R/FR) ratios. Previous results suggest that some plant species respond to changes in R/FR ratios in the absence of 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 factors fluctuate both spatially and temporally. Our objectives were to determine if crop-mediated changes in light quality are associated with early changes in weed morphology in the field and also if residual effects of the early R:FR environment were expressed later in the season, after mutual shading has occurred.

Two field experiments were conducted in 2004 at the University of Wisconsin-Arlington Agricultural Research Station to investigate the responses of common lambsquarters (CHEAL) and giant foxtail (SETFA) to altered R:FR ratios mediated by neighboring corn plants. Corn was planted in rows 0.76-m apart over one-half the study area; bare soil was maintained in the other one-half of the field. Standard agronomic practices were used for seed bed preparation, fertilization, and crop planting. At V5 corn, weed seeds were sown in 11.4-L pots containing 50:50 sand:silt loam; pots were placed 1.8-m apart in either the open area or between corn rows. Pots were watered and fertilized regularly; after emergence, weed seedlings were thinned to one per pot. Each experiment consisted of 156 weed plants (either CHEAL or SEFTA) subjected to one of four treatments: 1) early-season low R:FR, late-season shade, 2) early-season low R:FR, late-season no shade, 3) early-season high R:FR, late-season shade, and 4) early-season high R:FR, late-season no shade. Low R:FR ratios were mediated by corn rows, which were trimmed to maintain low R:FR ratios and to prevent shading of target weed plants. Late-season shade was provided by placing target weed plants (in pots) between corn plants in rows spaced 1.52-m apart. In the non-crop area, high R:FR ratios were maintained by controlling non-target weeds and by maximizing the space between target plants. Several times during the season, a spectroradiometer was used to measure the R:FR (645:735 nm) composition of horizontally propagated radiation at the apex of target weed plants in each treatment. Target weed plants were harvested at several times during the season to determine biomass allocation to leaves, stems, and roots. Analysis of variance and specific paired comparisons were used to assess the treatment effects on specific leaf area, specific main stem length, leaf to stem ratio, branch or tiller number, vertical leaf area distribution (CHEAL only), branch/tiller to main stem ratio, and root to shoot ratio.

For CHEAL, early-season low R:FR was associated with a vertical shift in leaf area, thinner leaves, less biomass allocated to branches than to stems, and lower mass per unit stem length when compared to plants exposed to early-season high R:FR. CHEAL plants subjected to late-season shade also exhibited vertical shifts in leaf area, thinner leaves, less biomass allocated to branches than to stems, and lower mass per unit stem length when compared to non-shaded plants; late-season shade was also associated with less biomass allocation to roots than to shoots. Additionally, shaded CHEAL plant responses did not differ with early R:FR exposure; likewise, non-shaded CHEAL plant responses did not differ with early R:FR exposure. For SETFA, early-season low R:FR was not associated with changes in biomass allocation, except leaves were slightly thinner than those of plants exposed to high R:FR. Late-season shaded SETFA plants had thinner leaves and less biomass per unit stem length than non-shaded plants; these responses did not differ with early R:FR exposure. Also, for shaded plants, less biomass was allocated to SETFA roots and tillers than to leaves when compared to non-shaded plants, but these responses differed with early-season R:FR exposure. These results indicate that CHEAL responds rapidly to altered R:FR, but that these early-season responses have little effect on late-season CHEAL morphology. In contrast, most SETFA responses to early-season R:FR exposure were apparent only after exposure to late-season shade and also differed with R:FR treatment. These results indicate that monocot and dicot plants may not only respond differently to early changes in R:FR ratios but also that the residual effects of early R:FR environment on late-season morphology (and thus competitive ability) may differ between monocots and dicots.

RESPONDING TO OHIO'S PLANT INVADERS. Sarena M. Selbo, U.S. Fish and Wildlife Service, Reynoldsburg, OH 43068.

Over the past couple of years, there has been a growing awareness of the problems that invasive species present to the protection of biodiversity in our natural areas. Invasives are the second greatest threat to rare species in the United States, following habitat loss and degradation. Approximately one-fourth of the plant species known to occur in Ohio originate from other parts of the continent or the world. These species are commonly called non-native, exotic or alien because they were not known from Ohio prior to the time of substantial European settlement, around 1750. Several agencies throughout Ohio have been involved in educating the public on this topic. In response to continued interest, a working group (soon to become a non-profit, Invasive Species Council) was formed to address some of the questions and information needs in Ohio. The main purpose of the Council is to gather together those individuals who have a shared interest in taking additional steps to address various aspects of the invasive species issues in Ohio. Participants in the Council include state, federal and local natural resource agencies, garden clubs, university researchers, arboretums, botanical gardens, the landscaping industry, and others. The working groups of the Council include: 1) education and public outreach, 2) control and restoration, 3) distribution and documentation, and 4) research and science. Ongoing actions of the working groups continue to educate the public and add to our understanding of invasive plant management in Ohio.

ABATING THE THREAT OF INVASIVE SPECIES; TNC'S INVASIVE SPECIES.
Ellen M. Jacquart, Director of Stewardship, Indiana Chapter of The Nature Conservancy, Indianapolis, IN 46202

The Nature Conservancy views invasive species as one of the greatest threats to biodiversity globally and is fighting this threat on a number of levels. From assessment protocols, prevention strategies, and early detection/rapid response initiatives to control and management projects, we are working to protect important biodiversity targets from invasive species. Examples of the Conservancy's work will be shared, including our partnership with other groups to form the new Midwest Invasive Plant Network.

CO-EVOLUTION IN PLANT-MICROBE ASSOCIATIONS AND THE CONSEQUENCES OF GEOGRAPHIC DISPLACEMENT. Steven G. Hallett, Assistant Professor, Department of Botany & Plant Pathology, Purdue University, 915 West State Street, West Lafayette, IN 47907.

Some plant species behave in a very unusual way when they are introduced into a new geographic area. They form dense populations that are uncharacteristic in their native range, and they replace vegetation types that are similar to those with which they co-exist in their native range. Although numerous hypotheses have been posited to explain plant invasions, few are universally satisfactory. In order to develop a universal theory of plant invasions, a number of researchers have investigated the consequences of plant geographic displacement from the perspective of the dislocation of plants from co-evolved relationships. Such relationships include those with mutualists, parasites and competitors. The evolutionary and ecological consequences of the loss of these relationships may be different in each case. This approach to the study of plant invasions will permit the consideration of the evolutionary responses of invaded communities concurrently with investigations of the ecology of plant invaders. Adoption of this perspective will improve our understanding of the evolutionary ecology of plant communities and our ability to predict and manage plant invasions.

ROLE OF DISTURBANCE REGIMES IN PLANT INVASION AND COMMUNITY CHANGE. Robert A. Masters, Rangeland Scientist and Product Technology Specialist, Dow AgroSciences, LLC, Lincoln, NE 68516.

A critical step in the invasion process is plant propagule dispersal into locations or microsites that provide conditions conducive to plant establishment. These locations where immigrant plants establish and develop are often referred to as safe sites, regeneration niches, or invasion windows. These safe sites must meet the requirements of the alien species for germination, growth, and development and enable the plant to reach reproductive maturity. Disturbance is often a driving force that facilitates creation of safe sites for invasive plant establishment. Disturbance is defined as any discrete event in time that disrupts ecosystem, community, or population structure, and changes resources, substrate availability, or the physical environment. Events that affect resource availability and community demographic processes such as fire, storms, floods, grazing management, and fertilization are considered disturbances. Disturbances associated with global change (global warming, increasing atmospheric CO_2, increasing nitrogen deposition, etc.) influence distributions of invasive plants. Disturbance is an important factor affecting community structure and dynamics that promotes invasion by exotic plant species, especially where disturbance disrupts species interactions and reduces competition and/or interference. Invasion success is dependent on the extent and type of disturbance, propagule pressure (number of alien plant propagules in the community and duration of community exposure to propagules) and time interval between disturbance events. Community susceptibility to invasion is increased when disturbances deviate from historical patterns because the resident species are likely not adapted to the new disturbance regime and species composition will shift to favor those beneficially affected by the disturbance. Developing effective and sustainable programs to manage invasive plants requires an understanding of plant community response to disturbance and manipulating disturbance regimes to favor desired species and successional trajectory.

THE ROLE OF LANDSCAPE AND LOCAL FACTORS IN PLANT INVASIONS.

Kevin D. Gibson, Assistant Professor, Department of Botany & Plant Pathology, Purdue University, 915 West State Street, West Lafayette, IN 47907

The invasion of sites or patches within a fragmented landscape like that found in the North Central region has two primary components. First, propagules of an invasive species must disperse from the regional species pool to a local site. Second, the species must establish and persist at the local site. Whether a species successfully invades a site depends on the interaction between propagule pressure (i.e. dispersal) at the landscape level and persistence at the local level. A number of hypotheses have been advanced to explain the success of plant invaders. Most of these focus on biotic interactions (competition, herbivory, parasitism, mutualisms, etc.) between invaders and native species that affect persistence. However, relatively few studies have addressed the effect of landscape factors such as patch size and connectivity on plant invasions. We will discuss the importance of dispersal and landscape factors to the invasibility of forests in the North Central region.

SHOULD WE CONSIDER SOME CROP WEEDS AS INVASIVE? Douglas Doohan, Associate Professor, Department of Horticulture and Crop Science, Ohio State University, 1680 Madison Avenue, Wooster, OH 44691.

Weed ecologists are an anomaly in the culture. Who else asks of a new plant species encountered in the field for the first time, 'is this the next big thing?'. That question and all it implies is couched within the word *invasive.* When we use the word invasive we are communicating to each other and to our stakeholders something ominous and potentially threatening about the species at hand. At the simplest level we are communicating that something is different and deserves close attention and possible action. The invasive designation also conveys powerful political content; in the sense of possible regulation and funding for research and containment. In the past we might have used the word noxious to describe similar species, conveying similar notions about the potential risks and opportunities.

Case histories are instructive as we consider the question. The witchweed (*Striga asiatica*) eradication program is an excellent example. The date of witchweed introduction to the US is unknown; however, symptoms of what later was confirmed to be witchweed parasitism of corn showed up in NC between 1946 and 1950 (Patterson 1990). The cause of the syndrome, described as an 'unknown disease of corn that caused symptoms similar to drought damage' was not identified until 1956 (Sands 1990). At the peak approximately 164,000 ha of land were infested in the Carolinas. More than $250 million of federal and state funds have been used to contain and eradicate the species. Fewer than 3000 ha are still in quarantine (Eplee 2001). Cost benefit studies strongly support the use of taxpayers funds in the witchweed program. The witchweed story clearly illustrates the importance of raising the alarm and using the appropriate terminology that is currently being accepted by the various stakeholders. If you don't agree immediately with this conclusion, imagine most of the cornbelt with witchweed (Patterson 1990).

The weed ecologists conundrum is distinguishing real threats from imaginary ones.
It should be no surprise that our professional opinion is far less important than that of our principal stakeholders, the farmers and ranchers of America. Farmers will not be convinced that a new weed should be taken seriously for many reasons. For one thing they are experienced in managing weeds and generally do not consider them particularly threatening or unusual. Also in the current research funding environment they are reluctant to see expenditures on problems that are not immediate. This is a form of the NIMBY (not in my back yard) mentality. Conflicting values and the resultant actions that various individual stakeholders, groups and agencies are willing to take are huge obstacles to managing invasive plants.

Characterizing the invasive potential of many species, enacting and enforcing regulations, surveillance, containment and eradication are costly to society and to individuals. Transferring costs to the future is also costly and in the case of invasive species the costs escalate as time marches on. Other costs, often overlooked in the management of agricultural resources, are externalities. Externalities are those costs that must be borne by other individuals and by society at large. In the case of invasive weeds of cropland those would include spread to non-infested land and possibly the need for more intensive herbicide application with associated off-target impacts. At Ohio State

University we hope to apply risk analysis to the challenge of aligning individual farmer incentives and the societal goal of preventing invasion. Risk analysis is composed of 3 steps: science level risk assessment, risk management (selection of policy instruments and evaluation of their effectiveness) and risk communication (an interactive exchange of information and opinions concerning risk among risk assessors, risk managers, consumers and other interested parties (Codex 1997)).

New weed species that show up in cropland should be considered potentially invasive. Most will likely prove to be innocuous. A few may permanently degrade the agro - ecosystem if allowed to spread. Much research is needed to develop better tools to characterize the invasive potential of species and the vulnerability of agro-ecosystems. Funding at this time is barely adequate to probe the relevant questions. Weed ecologists and those involved in weed management should carefully consider how to most clearly communicate the risk of invasive species of cropland and the benefits from prevention. In my opinion spending time interacting with the principle stakeholders – the farmers and ranchers of America is probably the key.

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WEEDS TO WATCH: WEEDS THAT SEEM TO BE EXPANDING THEIR HABITAT RANGE. William G. Johnson, Robert G. Hartzler, and Dawn E. Nordby, Assistant Professor, Department of Botany and Plant Pathology, Purdue University, W. Lafayette, IN 47907, Professor, Department of Agronomy, Iowa State University, Ames, IA 50011, and Extension Weed Specialist, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

Extension weed scientists in Iowa, Illinois, Indiana, Minnesota, Wisconsin, and Michigan have noted twelve weed species that appear to pose an increasing threat to agronomic fields. This information was assembled into a poster titled “Weeds to Watch” which is available online at http://weeds.cropsci.uiuc.edu/extension/Other/WeedstoWatch.pdf. Information on the poster includes color pictures to aid in identification, maps that provide information regarding current distribution of each species, brief text descriptions about why it is believed to be problematic and recommended control measures.

This presentation will focus briefly on pertinent biological and control issues for each weed listed on the poster. In addition, we will utilize field survey results to determine how often these species were found in Midwest soybean fields during late-season surveys.

We conducted an extensive survey of soybean fields the fall of 2004 to determine the identity, density, and distribution of late season weed escapes in Iowa, Illinois and Indiana. In each state, a minimum of 30 fields were sampled. Fields were distributed throughout each state and sampled by following an inverted W-pattern. Ten locations along each arm were sampled for a total of 40 sampling units per field. At each sample stop, the identity and density of each weed specie in 0.5 square meeter quadrat was recorded.

Six of the twelve weeds on the Weeds to Watch poster were commonly found in the fall of 2004. Common lambsquarters, giant ragweed, and waterhemp were found in more than 10% of the fields sampled in two out of the three states. Purple deadnettle, common pokeweed, cressleaf groundsel, and burcucumber were found less frequently. Key biological characteristic of these weeds include germination patterns which allow them to become too large to control with postemergence herbicides or they emerge after after postemergence herbicides are applied. The presence of stalk boring insects has been noted in common lambsquarter, giant ragweed, and common waterhemp and preliminary evidence suggests that insect infested plants are more difficult to control with glyphosate. In conclusion, adjustments in management practices will be needed to reduce the occurrence of yield losses due to these weeds.

WHY CROP WEEDS SHOULD NOT BE CONSIDERED INVASIVE. Robert G Hartzler, Department of Agronomy, Iowa State University, Ames, 50011.

Alien species, such as giant foxtail, velvetleaf and common cocklebur, have cost Midwest farmers billions of dollars in yield losses and the need for increased control tactics (herbicides, tillage, etc.). There is no doubt that additional species capable of invading North American agronomic fields reside on other continents. The purpose of this talk is not to belittle the importance of these alien threats, but to make the case that invasive plants pose a greater threat to non-managed landscapes (prairies, woodlands, etc.) than agronomic fields. Weeds are an inherent component of crop production systems, and repeated disruptive tactics are required to maintain weeds below economic levels. The biological traits that favor invasion of agronomic crops typically are different than traits that favor invasion of areas with less frequent disturbance, thus most agronomic weeds are not successful at invading non-disturbed habitats. The tactics used to manage agronomic weeds usually do not discriminate between alien and native plants. Thus, native plants are just as problematic for farmers as aliens. While the introduction of a new alien might force changes in the type of management strategies used, it is unlikely that this introduction would cause a significant increase in the inputs needed to manage weeds. In contrast to agronomic fields, habitats that are not continuously disturbed have relatively stable plant communities and should not require repetitive intervention to manage weeds. Introduction of invasive species adapted to these ecosystems can result in the need for implementation of disruptive control tactics where previously intervention was not required.

Farmers are continually faced with weed shifts that force changes to weed management programs, and these shifts usually occur without introductions of new species. The rise in importance of giant ragweed and waterhemp, two native ruderals, illustrates the adaptive nature of successful weedy species. Based on the number of citations in the NCWSS Proceedings, research projects investigating these two weeds increased 43 fold between 1982 and 2003. Several factors likely are responsible for the rise in importance of these two species, some associated with changes in crop production practices, and some due to weedy adaptation. The evolution of herbicide resistance in waterhemp is one factor contributing to its rise as a dominant weed in many states (IA, IL, KS, MN, MO). Biotypes possessing resistance to three different sites of action have eliminated the majority of herbicide options for controlling this weed in soybean. While the historic range of waterhemp extends across the North Central region, the spread of ‘difficult to control’ waterhemp can be tracked across the region much like a newly introduced species. Management problems with waterhemp were first reported in MO and southern IL in the mid to late 1980’s, and during the 1990’s the ‘problem’ biotypes spread to the west, north and east. The reason for this pattern of range expansion is unclear. Giant ragweed presents another example of adaptation of a native plant with weedy characteristics. Giant ragweed is considered the primary weed problem for farmers in OH and IN, but the species diminishes in importance moving west across the region. Differences in emergence patterns of giant ragweed across the region are strongly correlated with the magnitude of problems caused by the species. Research suggests emergence characteristics favorable for survival in agronomic fields evolved first in the eastern Cornbelt and are moving westward.

The rise in importance of waterhemp and giant ragweed illustrate that adaptations in established native species can be as problematic as the introduction of a new alien plant, and result in the need to continually modify weed management systems. The cost associated with invasions of less intensively managed areas can be much greater that of agronomic fields where control measures are already needed. Because of this, I believe research and regulatory efforts should focus on species adapted to natural areas rather than species adapted to cropland.

PROGRESS IN WISCONSIN WITH INVASIVE WEEDS. Jerry D. Doll, Extension Weed Scientist, Department of Agronomy, University of Wisconsin, 1575 Linden Dr., Madison, WI 53706.

The Wisconsin Noxious Weed Law, adopted in the 1970s, never functioned well because it lacked a mechanism for adding and deleting species, did not attempt to educate or train, only focused on agricultural settings, and lacked financial support. So this failed to be effective because even though we had rules on the books, we had no way to develop a functional program. In 1999, we formed a working group with approximately 25 people that represented nearly all areas interested in invasive plants to reinvent a functional noxious weed program to replace our defunct law. We reached the point where we had a consensus as to what the program should contain and how it would function and the document went to the Legislative Reference Bureau of our state government to be transcribed into legislative language. This proved to be a daunting task and when the state budget crisis of 2003 hit, progress to take the effort forward ceased and to date it has not been introduced into the legislative process for approved and implementation.

In contrast to the old day, the new one will 1) allow for annual modifications, 2) establish prohibited, restricted and watch categories at the state and county levels, 3) create a Noxious Weed Board, 4) include education and research as significant components, 5) provide funding to subsidize the costs of combating prohibited species, and 6) assign responsibilities within government agencies regarding implementation and execution of the law. More than a year transpired with no movement in the legislature to consider our proposal so it lay dormant during this time.

Nevertheless, the efforts to organize, educate, monitor and manage invasive species are anything but dormant due in large part to a relatively new development on the invasive plant scene in Wisconsin. That is the creation of the Invasive Plants Association of Wisconsin (IPAW) in 1999. IPAW has convened two well attended biennial conferences on invasives and we are starting to systematically document the location of invasive plants, and we are providing education on invasives via the IPAW web site (http://www.ipaw.org/), conferences, printed word, and field demonstration. Federal monies are subsidizing the control of multiflora rose. The state Departments of Transportation and of Natural Resources are cooperating to control leafy spurge along roadsides. Local groups are tackling purple loosestrife with biocontrol agents and biennials like wild parsnip with mechanical and chemical means. With such efforts, we are holding our own on several fronts.

In early 2004, our governor appointed and Invasive Species Council. The Council has subcommittees that tackle research, education, regulations and interagency issues but they have no budget so the impact will be limited in the near term. The Council meets regularly, has momentum and at least keeps the invasives issues on the legislative radar screen. The Council has a mandate to give the state legislature a report in February 2005 that will describe the mechanism and criteria by which a species would be classified according to its invasiveness. The efforts of the Noxious Weed Task Force in developing the criteria and categories of noxious weeds will dovetail nicely into this mandate and we have offered our blueprint to the Council. Ours may well be the blueprint for other invasive species.

Wisconsin now has a mechanism for reporting new invasive weeds in the state. And it's just in time. Giant hogweed invaded via the Upper Peninsula of Michigan, hill mustard (also known as Turkish warty cabbage) has appeared on our southern border and devil's claw appeared in a garden on our western border. This is a great step forward and allows anyone in the state to register as an official "weed watcher." A full explanation of the system is found at: http://dnr.wi.gov/org/land/er/invasive/futureplants/. This will be a very fruitful venture as many members of The Nature Conservancy, Prairie Enthusiasts, The Wild Ones, Master Gardeners and similar organizations will eagerly become watchers and report introductions and movements of invasive plants.

As Rome took awhile to emerge, so it is with our efforts in Wisconsin to develop a fully function invasive weed program. We remain optimistic that such a program will arise and regardless of the pace of action at legislative and administrative levels, the troops at the grass roots level are fully engaged and doing the best they can under the limitations we face.

NATURAL HISTORY OF SEEDBANKS OF ARABLE LAND. Carol C. Baskin and Jerry M. Baskin, Professor, Department of Biology and Department of Agronomy, University of Kentucky, Lexington, KY 40506 and Professor, Department of Biology, University of Kentucky, Lexington, KY 40506.

Seeds that remain ungerminated and viable in the soil until the second or some subsequent germination season become part of the persistent soil seed bank. The number of weed seeds in the persistent soil seed bank may be 6500 m^{-2} or higher, and, depending on the species, seeds may live in the soil for up to 30-40 years or even longer. It has long been known that if arable soils are disturbed at regular intervals buried seeds of many, but not all, weeds have a predictable germination season. For seeds that are permeable to water, explanations for the various germination phenology patterns have come from studies in which seeds were buried in soil under natural seasonal temperature changes. In these studies, seeds were exhumed at monthly intervals, and their responses to a range of alternating temperatures and to light/darkness were determined. Buried seeds may cycle between dormancy (do not germinate at any conditions) and nondormancy (germinate over a wide range of conditions), or they may cycle between conditional dormancy (germinate at a narrow range of conditions) and nondormancy. The time of year when seeds are nondormant varies with the species, i.e., autumn, spring, or spring-summer. A light requirement for germination plays an important role in preventing nondormant seeds from germinating in the soil. Soil disturbance that exposes seeds to light must occur at a time of year when seeds are nondormant or nearly so, i.e., in late state of conditional dormancy; otherwise, they can not germinate. Buried seeds of some species come out of dormancy and remain nondormant regardless of yearly seasonal changes in environmental conditions. However, these seeds do not germinate in the soil because they require light for germination.

Seeds with water-impermeable seed coats, e.g., weedy members of Fabaceae and Malvaceae, also can form persistent soil seed banks. Seeds of these species have a water gap in the seed coat that serves as an environmental signal detector for them to germinate. Under appropriate conditions, the water gap opens, thereby allowing water to enter, and the seeds germinate. Soil disturbance that results in seeds being brought to the surface, where maximum temperatures as well as the difference between day and night temperatures are higher than those in the soil, can cause the water gap to open. Consequently, the water gap indirectly serves as a depth sensor.

Thus, knowing what regulates the timing of germination of weed seeds buried in the soil allows us to predict when they will germinate if brought to the soil surface.

THE STRATEGIC SIGNIFICANCE OF THE SEEDBANK. Edward C. Luschei, Assistant Professor, Department of Agronomy, University of Wisconsin – Madison, Madison, WI 53706.

From a demographic viewpoint, the formation of persistent seedbank is a risk-reducing or bet-hedging strategy that trades the potential fitness advantage of a short generation time with the certainty of a floor on the minimum population growth rate. The minimum population growth rate is often as high as 0.5 for many annual weeds, making local extinction times, without immigration and with 100% plant mortality, on the order of decades. The fundamental questions of this symposium are (1) if management actions could lower the floor on the growth rate, would those actions make sense as a way to invest our management resources? (2) given that most seeds are relatively invulnerable to physical and chemical attack, what methods might we employ to lower the floor on their growth-rate? We investigate one aspect of the first of these two points by considering the population biology of horseweed. More specifically, we demonstrate how the seedbank and immigration influence the time required before resistance allele frequencies, ρ_r, achieve their half-saturation point (T_{50}). While seed immigration rates at the early stages of invasion function as spatial refugia, reducing ρ_r directly by diffusive dilution, both the seedbank and resistance management strategies create temporal refugia capable of lengthening the T_{50}. For this reason, the strategic advantage of a seedbank for annual weeds, namely maximizing long-run fitness by establishing a floor on the growth rate, can also be viewed as “built in” resistance management strategy. Using analytical work on resistance from the 1970s and 80s, as well as individual based models, we explore this trade-off using current best estimates for horseweed demographic rates.

WHEN DOES TARGETING WEED SEEDBANKS MAKE SENSE? Adam S. Davis, USDA-ARS, Urbana, IL, 61801.

Weed management tactics generally target the seedling stage of the weed life cycle. Controlling weed seedlings reduces the potential for crop yield loss due to weed interference and also has the potential to reduce the number of weed seeds that enter the soil seedbank. Moreover, there are numerous, cost-effective ways of killing weed seedlings. When, if ever, does it make sense to deploy management tactics targeted directly at weed seeds? The weed science literature contains relatively few examples of seedbank dynamics having an impact upon weed management outcomes. This may be due partially to lack of cost-effective methods for seedbank management, and partially to the complex, labor-intensive studies necessary to understand weed seedbanks. To assess the potential for weed seedbank management to influence overall weed management success, a variety of scenarios were run with matrix population models using published values for weed demographic rates. Simulations were performed for two annual weeds of arable fields, giant foxtail and common lambsquarters, a biennial weed of woodland habitats, garlic mustard, and a perennial weed of arable fields, Canada thistle. Scenarios explored how variation in life history, efficacy of control tactics aimed at weed seedlings and plants, fecundity and seed longevity affect the importance of seedbank control measures for reducing weed populations. For giant foxtail and common lambsquarters, over a wide range of conditions, changes in overwinter seed survival had a larger impact on population growth rate than changes in other demographic rates. Survival of dormant seed in summer months had the lowest impact of any demographic parameter on population growth rate of giant foxtail and common lambsquarters. Increased mortality of newly shed giant foxtail or common lambsquarters seed could directly compensate for reductions in efficacy of seedling control for these species. For both garlic mustard, and Canada thistle, survival of rosettes to the flowering stage had the greatest regulatory control over population growth, and survival of seeds in the soil seedbank had the lowest importance. Factors influencing inputs of new seeds into the soil seedbank, however, had an effect on population growth rate that was second in importance only to rosette survival for both garlic mustard and Canada thistle. Simulation models will be useful in developing weed seedbank management strategies that complement control tactics aimed at aboveground life stages.

HOW CAN WE TARGET THE WEED SEEDBANK? Eric R. Gallandt, Assistant Professor, Department of Plant, Soil and Environmental Sciences, University of Maine, Orono, ME 04469-5722.

Strategies to manage the weed seedbank may be considered within the broad categories of reducing seed inputs, increasing seed losses, and reducing the likelihood of establishment. Herbicides and cultivation aim foremost to reduce crop yield loss, but, by reducing weed density and offering a competitive advantage the crop, they further reduce weed biomass and seed inputs. Likewise, cover crops may be planted to preempt niches otherwise occupied by weeds thereby reducing weed biomass and seed inputs. However, the extraordinary reproductive potential of annual weeds suggests that strategies focused solely on reducing seed inputs should be supported by efforts to increase losses from the seedbank and to reduce the probability that remaining seeds establish.

Germination, predation, and decay are the primary sources of loss to the seedbank that may respond to management. Farmers have long prepared stale seedbeds in which shallow soil disturbance encourages germination losses. Decision aides that integrate information about weed biology with real-time environmental conditions could optimize the efficacy of this practice. Post-dispersal seed predation by vertebrate and invertebrate granivores may cause high rates of seed mortality in a wide range of cropping systems, but asynchronous seed dispersal and predator activity and seed burial may limit the overall effect on the seedbank. Although seeds would seem to be an ideal carbon source for soil microorganisms, the evolutionary success of many annual weeds rests in their ability to resist decay and produce a persistent seedbank. Limited evidence from a study of wild oat (*Avena fatua* L.) suggests that decay may be less responsive to management than germination, and likely predation.

A final management objective, supporting a program which aims to reduce seedbank inputs and increase losses, is to reduce the size of the effective seedbank through manipulation of residues and disturbance to reduce the probability of establishment. Incorporation of green manures generally reduce weed establishment whereas larger-seeded or transplanted crops may better tolerate the residue-mediated changes in the chemical, biological and physical properties of the soil surface environment. Evidence from no-till systems further support the hypothesis that changes in soil surface conditions may regulate the abundance of “safe-sites” for weed establishment thereby modulating the size of the effective seedbank.

PROSPECTS OF WEED SEEDBANK REGULATION BY SEED PREDATORS. Paula R. Westerman, Matt Liebman, Fabián D. Menalled*, Andrew H. Heggenstaller, and Megan O'Rourke, Postdoctoral Scientist, Professor, Assistant Professor, Graduate Research Assistant, and Graduate Research Assistant, Department of Agronomy, Iowa State University, Ames, IA 50011-1010, and *Department of Land Resources and Environmental Sciences, 719 Leon Johnson Hall, Montana State University, Bozeman, MT, 59717-3120.

There is a growing body of evidence showing that seed predators consume a large proportion of the weed seeds produced in arable fields. At the same time, an increasing number of modeling studies show that post-dispersal losses have a major impact on long-term weed seed bank densities. Consequently, seed predation is a natural addition to applied weed control, and farmers may consider measures to favor it. However, because we are only beginning to understand the factors influencing seed predation, we do not yet know how to favor seed predators or enhance seed mortality due to predators. Post dispersal seed losses vary considerably, both spatially and temporally. Detecting patterns and elucidating causes of variability may be keys to understanding and utilizing seed predation in biological weed control. Here, we will mainly focus on patterns emerging from seed predation trials done in experimental and commercial cereal and sugarbeet fields in the Netherlands and in a field experiment in Boone, IA, comparing corn, soybean, triticale and alfalfa in 2-, 3-, and 4-yr crop rotation systems. Patterns emerging from these trials will be supplemented with data available in the literature.

Seed losses due to predation are a function of the intersection between temporal patterns of seed predation ('demand') and seed availability ('supply'), as defined by both seed deposition and seed residence time on the soil surface. Temporal patterns of seed predation in spring, summer and autumn are related to changes in the numbers and activity of seed predators present in the field, which appear to be positively correlated with the amount of crop canopy present (Iowa and the Netherlands). Seed deposition differs among weed species, crops and climates; differences in the potential annual losses due to predation among weed species are mainly caused by differences in the timing of seed shed (the Netherlands). Preliminary data, furthermore, indicate that predation rates in winter are high, despite the absence of a canopy (the Netherlands). Seed burial can be accomplished by tillage, which varies among crops and rotations. In no-till situations, seed burial is caused by natural causes. Preliminary trials in Iowa and the Netherlands have shown that seed size, crop type, rotation system and weather conditions are important in the process of seed burial.

At least part of the variability in seed predation is the result of the involvement of different groups of seed predators. The principal seed predators can be either vertebrates, such as birds and rodents (the Netherlands, Iowa), or invertebrates, such as slugs, ants, ground beetles (the Netherlands), and crickets (Iowa). These groups differ in numbers, activity, mobility, food requirements, food and habitat preferences, and population dynamics. While it is likely that they respond differently to crops, crop management practices, and tillage regimes, it is currently unknown what factors determine the presence or absence of certain groups of predators at specific locations.

Seed preference in relation to seed availability is an unresolved issue. Preliminary evidence suggests that rodents are less choosy when seeds are scarce, and that they show preference when food is abundant (The Netherlands). Invertebrates, such as crickets and ground beetles, show a clear seed preference in laboratory trials with abundant seed (Iowa). Seed abundance should also affect the numbers and behavior of predators (numerical and functional response) and the predation rate (density dependent response). The scale at which these processes take place depends on the mobility of the principal predators. For example, the addition of a large amount of weed seeds to cereal plots caused an increase in seed demand in the Netherlands, where rodents were prevalent.

Understanding the temporal patterns of seed demand and supply provides the best opportunities to manipulate and maximize weed control by seed predators. Of the above factors, the farmer may be able to use crop choice, rotation system, and tillage regime as tools to facilitate natural weed control.

DO MICROBES INFLUENCE SEEDBANK DYNAMICS? Joanne C. Chee-Sanford and Gerald K. Sims, Microbiologist, U.S. Department of Agriculture-Agricultural Research Service, Urbana, IL 61801 and Microbiologist, U.S. Department of Agriculture-Agricultural Research Service, Urbana, IL 61801.

The abundance and persistence of seeds of many annual weed species in soil offer a variety of potential interactions to occur between seeds and native soil microorganisms. These interactions may include mechanisms of neutralism, mutualism, or antagonism, where combinations of various biotic and abiotic factors could influence both the development and outcome of these relationships. Generally, microbial interactions with seeds have not been considered within the context of ecological relationships involving plants and the surrounding multi-trophic community. Soil microorganisms (bacteria and fungi) are known for their importance in processes such as nutrient and mineral cycling, residue turnover, xenobiotic degradation, and plant health and development. A number of microbial species involved in these processes have been well-studied, however, it is estimated that 95-99% of all microbial species that are present in the environment remain uncharacterized, with their corresponding ecological functions unknown. Much of the challenge in studying microbial communities in natural environments has been due to the lack of suitable methods available to examine microorganisms at relevant scales of measure. Previous studies that investigated in particular, microbial associations with seeds, relied on cultivation-based methods that often selected for cultivatable species with faster rates of growth or those present in higher abundance. This approach frequently missed important species and underestimated the diversity of microorganisms that were present, but did allow limited population sets to be identified and examined for their physiological function. More contemporary molecular-based methods have been developed in recent years to circumvent the limitations of cultivation bias, and provide some useful and more accurate tools to investigate important microbe-seed relationships that may be missed using traditional methods. To address the question of whether microbes influence weed seedbank dynamics, we need a more thorough characterization of the microorganisms involved in seed interactions, and to understand the fundamental factors and mechanisms that regulate and drive seed-related microbial processes in soil. Further, we need to consider seed-microbe interactions as mutually dynamic processes, thus there is also a need to investigate any intrinsic qualities possessed by seeds that may also significantly influence these relationships.

Microbial-mediated seed decay has received recent attention as a mechanism of interest that may be exploited and aimed at promoting depletion of weed seedbanks. Current studies in our lab are looking at aspects of seed decay. For example, we recently reported studies conducted to determine the potential extent of seed decay under conditions where seeds provided the major source of carbon nutrition for microbial populations. As a continuing working hypothesis, seeds provide rich carbon nutritional resources for the general extant soil microbial community, available for cell metabolic use under the following conditions: 1) if other essential nutrient limitations are absent, 2) if key microbial species are present with enzymatic capabilities that enable access to seed components, and 3) if intrinsic mechanisms of seed protection, whether present, are overcome. We generally observed a range of seed decay following exposure to soil microorganisms, with up to 99% of velvetleaf seeds undergoing decay under conditions of both nutrient selection and non-selection, and significantly more recalcitrance (≤10%) in seeds of giant ragweed, common ragweed, Pennsylvania smartweed, shattercane, wild buckwheat, wild oats, wooley cupgrass, and jimsonweed. Using molecular microbial analyses, we found the dominant bacteria identified in association with velvetleaf and other weed seeds were related to species common in soil, including predominant species belonging to the major phyla *Bacteroidetes* and *Proteobacteria*, many of which have key characteristics of surface attachment and polymer degradation abilities. Further, regardless of soil inoculum, decay of velvetleaf seeds was consistently extensive, but microbial communities varied on individual seeds, suggesting that different assemblages can fill a similar functional niche (seed decay). High resolution microscopic analysis has also been a critical tool in providing direct visual examination of microbial community assembly and seeds during the decay process, as well as seeing the spatial topography of cellular attachment and growth related to the biochemical and structural complexities of seed surfaces. For example, we can observe dense microbial biofilms even on non-decayed seeds of velvetleaf, suggesting a seed-derived source of nutrition is provided for some microbes in the absence of any obvious detriment to the seed. While our studies support a high potential for velvetleaf seed decay to occur in soil, extensive seed longevity and survival is known to occur for this weed species in natural seedbanks, suggesting that factors, as yet undefined, are present in soil that control and regulate microbial seed decay processes. Fungi are also considered in microbial associations with seeds. While there are no apparent specific relationships yet emerging between species of bacteria and seeds, we observed contrasting results with soil fungal populations. A predominance of members of the major fungal phylum *Ascomycota* have been found on seed surfaces of velvetleaf, wooley cupgrass, and Pennsylvania smartweed following microbial exposure, and these were specific relationships regardless of soil origin and the presence of diverse bacterial communities also on the seed surfaces. Species closely related to members of the genera *Chaetomium* and *Cephaliophora*, were found predominant on wooley cupgrass and velvetleaf seeds, respectively, with well-characterized species of these fungi known to occur in soil. Seeds of Pennsylvania smartweed were dominated by close relatives of *Cordyceps sinensis*, a species known for its production of bioactive substances and primarily found as an entomoparasite in other studies. The specific role of these fungi in weed seed associations is unknown and is presently being further investigated.

The types of studies we are currently conducting investigate the fundamental interactions between native soil microorganisms and weed seeds. Knowledge of the presence, identity, distribution, and relative abundance of important microbes and the activities that can affect seed fate is needed, along with understanding the consequent effects on plant development and weed demography. We also have initiated studies to examine the role of seed architecture and production of exudates on microbial populations and community assembly on seed surfaces. An ongoing effort is also being made using parallel molecular and cultivation strategies to identify key microbial species that specifically initiate seed decay processes. By understanding the mechanisms of action between seeds and naturally occurring soil microorganisms, and how these actions are affected by changes in their environment, we may be able to more accurately predict effects on plant development or the extent of seed loss that can be attributed to microbial activity across a broad range of natural soil systems. As our understanding increases, we can evaluate the potential for enhancing microbial processes that target desireable effects on seeds, and as a long term goal, develop practical strategies for seedbank modification as a component of biological-based weed management.

Italian Ryegrass As A Potential Tool To Manage Winter Annual Weeds And Soybean Cyst Nematode.
Mark M. Menke*, S. Kent Harrison, and Ramarao Venkatesh, Graduate Research Associate, Professor and Research Associate, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210.

Soybean cyst nematode (SCN) causes more economic damage to U.S. soybean producers than any other soybean pathogen. Purple deadnettle, a common winter annual weed in the eastern U.S. Corn Belt, is an alternate host of SCN. We are investigating the potential of Italian ryegrass (*Lolium multiflorum*) as a cover crop for suppression of purple deadnettle. In a field experiment, there was an approximate 3-fold decline in purple deadnettle population density across all treatments from November 2003 to April 2004. Purple deadnettle population densities were suppressed 55% by Italian ryegrass from November through April. In a greenhouse experiment, replacement series analysis of Italian ryegrass-purple deadnettle mixtures indicated a strong compensatory reaction in which Italian ryegrass increases in shoot dry weight were significantly greater than those expected in monoculture, and these increases were offset by corresponding reductions in purple deadnettle shoot dry weight. At a constant density of 16 plants per pot, Italian ryegrass proportions of 25 and 75% comprised 72 and 97%, respectively, of the total shoot biomass in Italian ryegrass-purple deadnettle mixtures. These data indicate that Italian ryegrass strongly suppressed purple deadnettle establishment and growth; however, reduced populations of purple deadnettle in Italian ryegrass were capable of persisting over the winter and reaching maturity in the spring. First-year results suggest that weed control measures in addition to an Italian ryegrass cover crop may be necessary to prevent SCN reproduction on purple deadnettle.

SOYBEAN CYST NEMATODE AND WINTER ANNUAL WEEDS IN INDIANA: DISTRIBUTION AND PRODUCER CONCERN. J. Earl Creech and William G. Johnson, Graduate Research Assistant and Assistant Professor, Purdue University, West Lafayette, IN 47907.

Soybean cyst nematode (SCN) is a threat to profitable soybean production in Indiana and throughout the soybean growing regions of the U.S. Research has shown that a number of winter annual weed species can serve as alternate hosts for SCN. However, the presence of winter annuals in SCN infested fields has not been documented. The objectives of this research were to (1) document the distribution of winter annual weeds in SCN infested fields in Indiana and (2) assess grower concern regarding SCN and its potential interaction with winter annual weeds. A field survey was conducted in the spring of 2004 in 72 grower fields throughout Indiana. These fields were selected from those identified from previous statewide sampling surveys to be infested with SCN. The winter annual weeds that occurred with the highest frequency (in % of fields sampled) were common chickweed (87%), speedwell (84%), buttercup (58%), henbit (53%) and purple deadnettle (49%). Winter annual weed hosts of SCN were common in grower fields and many of these weeds were present at very high densities (100 or more plants m^{-2}). A second survey was conducted in winter 2003-04 to assess practices and attitudes regarding SCN and winter annual weeds in Indiana. Questionnaires were distributed to 3000 farmers and 750 attendees at Certified Crop Advisor (CCA) meetings. Statewide, 86% of CCA's were aware that some winter annual weeds could serve as hosts for SCN compared to 62% of producers. Also in the survey, 62% of producers expressed moderate to high levels of concern about SCN impacts on their soybean production; but only 39% employed management practices specifically aimed at managing SCN and merely 21% of soybean producers reported having had their fields sampled for SCN.

SOYBEAN ROW SPACING AND POPULATION AFFECT WEED GROWTH AND SOYBEAN YIELD. Dana B. Harder, Karen A. Renner, Christy L. Sprague, and Kurt D. Thelen, Graduate Research Assistant, Professor, Assistant Professor, and Associate Professor, Michigan State University, East Lansing, MI 48824.

Planting soybean in narrow-row widths is a cultural weed management practice, but the recommended seeding rate is 25-50% greater than the seeding rate for wide-row soybean. Soybean producers may reduce soybean seeding rate in narrow row soybean as a way to lower input costs since soybean has the ability to compensate for low populations by increased branching and pod set, resulting in yield similar to soybean planted at a higher population. Studies were initiated to determine the effect of soybean population and row width on soybean yield in the presence and absence of weeds. Field studies were conducted at three locations in 2004. Soybean was planted in 19, 38, and 76 cm rows and thinned to populations of 197,600, 296,400, and 444,600 plants ha^{-1} at St. Charles, and 123,500, 185,250, and 308,750 plants ha^{-1} at Clarksville and East Lansing. Leaf area index (LAI), an indicator of canopy closure, was recorded every 7 to 14 days from late June to late August. At Clarksville, LAI was greater for soybean planted in 38 cm rows 81 days after planting compared to 19 and 76 cm rows. Weed-free yield was similar for soybean planted in 19 and 38 cm rows at 308,750 plants ha^{-1}, but yield was greater at 308,750 plants ha^{-1} in 76 cm rows compared to the other two populations at Clarksville. At St. Charles, LAI was significantly lower for soybean planted in 76 cm rows at 444,600 plants ha^{-1}, compared to soybean planted in 19 and 38 cm rows. Weed-free soybean yield was similar between populations in each row width at St. Charles. However, soybean yield in the weed-free 19 and 38 cm rows planted at populations of 296,400 and 444,600 plants ha^{-1} was greater than soybean yield in the same population planted in 76 cm rows. Weed biomass at Clarksville and East Lansing was similar in 19 and 38 cm row widths, and was reduced compared to weed biomass in 76 cm rows, regardless of soybean population. Similarly, soybean planted in 19 cm rows at St. Charles decreased weed biomass compared to the other two row widths at 296,400 plants ha^{-1}. Soybean yield loss from weeds was greater when soybean was planted in 76 cm rows at populations of 185,250 and 308,750 plants ha^{-1} at Clarksville, and for all populations at St. Charles in comparison to the other two row widths. Furthermore, soybean yield loss from weeds was greater at the low population of 296,400 plants ha^{-1} compared to the high population of 444,600 plants ha^{-1} in each row width at St. Charles. Therefore, the benefit of increased soybean seeding rates was evident only when weeds were not controlled at 2 of the 3 locations.

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CONTROL OF PROBLEMATIC COMMON RAGWEED WITH GLYPHOSATE AND ALTERNATIVE HERBICIDES IN SOYBEAN. Justin M. Pollard*, Brent A. Sellers, and Reid J. Smeda, Graduate Research Assistant, Post Doctoral Research Assistant, and Assistant Professor, Department of Agronomy, University of Missouri, Columbia, MO 65211.

A population of common ragweed has been identified resistant to glyphosate in Missouri. Field experiments were designed to evaluate herbicide management options in glyphosate-resistant soybean. The site containing the resistant population was used as one location and a site containing a susceptible population was used as a second location. Labeled rates of lactofen, chlorimuron-ethyl, cloransulam-methyl, imazethapyr, and bentazon were evaluated alone and tank mixed with 0.84 kg ae/ha (1X) of glyphosate. In addition, glyphosate alone at 1X and 2X rates were applied; an untreated control was also included. Herbicide applications were made when common ragweed reached a height of 12 cm. The experimental design was a randomized complete block with five replications at the resistant site and four replications at the susceptible site. At the time of application, up to 20 common ragweed plants were flagged in each plot, with 50% of the flagged plants harvested at ground level 3 weeks after treatment (WAT), and the remaining plants harvested 6 WAT. All of the treatments significantly reduced mean plant dry weight compared to the untreated control. At 3 WAT, glyphosate at 1X and 2X rates resulted in 68 and 75% reductions of common ragweed dry weights, respectively, compared to the untreated control at the resistant site. Tank mixes of cloransulam-methyl, chlorimuron-ethyl, bentazon, imazethapyr, and lactofen with glyphosate at 1X resulted in common ragweed dry weight reductions 13 to 55% greater than glyphosate alone at 1X. At 3 WAT, applications of chlorimuron-ethyl, imazethapyr, cloransulam-methyl, bentazon, and lactofen were less effective than glyphosate alone at the 1X and 2X rates. At 6 WAT, single applications of glyphosate at the 1X and 2X rates reduced common ragweed plant dry weight by 85 and 92%, respectively, compared to the untreated control at the resistant site. Application of chlorimuron-ethyl, imazethapyr, cloransulam-methyl, bentazon, and lactofen were less effective than glyphosate alone at 1X. With the exception of bentazon, tank mixes of the aforementioned herbicides with glyphosate at 1X reduced common ragweed dry weight 14 to 56% compared to glyphosate alone. Common ragweed mean plant dry weights at 3 and 6 WAT were lower at the susceptible location when compared to the resistant location, with the exception of bentazon at 6 WAT. At the resistant site, there were no differences in soybean yields between plots treated with glyphosate alone at the 1X and 2X rates along with the glyphosate tank mixes. However, yield was significantly lower where lactofen, chlorimuron-ethyl, cloransulam-methyl, imazethapyr, and bentazon were applied alone. Soybean yield was similar among treatments at the susceptible site; likely a reflection of the effectiveness of the chemical control program.

THE EFFECT OF VARIETY, PLANTING DATE, AND WEED HEIGHT ON WEED CONTROL AND GRAIN YIELD OF GLYPHOSATE-RESISTANT SOYBEAN. Ronald F. Krausz and Bryan G. Young, Researcher and Associate Professor, Department of Plant, Soil and Agricultural Systems, 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 soybean variety, planting date, and weed height on weed control in glyphosate-resistant soybean. None of the herbicides caused soybean injury. Soil herbicides followed by glyphosate or glyphosate alone at 1.12 lb ae/A controlled fall panicum, giant foxtail, yellow nutsedge, common ragweed, common waterhemp, velvetleaf, ivyleaf morningglory, common cocklebur, and Pennsylvania smartweed, 93 to 100%, regardless of planting date or weed height. No sequential applications of glyphosate were required to maintain 90% or greater weed control through out the growing season. Weed competition did not reduce soybean height or maturity, regardless of variety or planting date. Within each planting date, in the hand-weeded plots, there were no differences in grain yield among varieties with yield ranging from 55 to 62 bu/A. Delayed-planting reduced grain yield 1 to 3 bu/A. Postponing the application of glyphosate until weeds were 20 to 25 inches tall consistently reduced soybean grain yield. Despite 90% or greater weed control with a single glyphosate application, grain yield was reduced an average of 7.5 bu/A or 13% across varieties and planting dates.

POTASSIUM ADDITIVE COMPATIBILITY WITH GLYPHOSATE. Kelly A. Nelson and Peter P. Motavalli, Assistant Professor, Department of Agronomy, University of Missouri, Novelty, MO 63460 and Assistant Professor, Department of Soil, Environmental, and Atmospheric Science, University of Missouri, Columbia, MO 65211.

Research was conducted in 2003 and 2004 to determine soybean yield response and salt injury from foliar-applied potassium (K) fertilizer sources; assess if K fertilizer source affects weed control when mixed with a glyphosate-based herbicide; and evaluate the cost-effectiveness of applying K fertilization with glyphosate-based herbicides for no-till, glyphosate-resistant soybean production. Commercially available dry K fertilizer sources were applied with glyphosate at the maximum rate limited by the solubility of the product. Liquid fertilizer sources were applied as the carrier with glyphosate. All treatments except potassium carbonate had less than 10% injury 7 and 14 days after treatment. Potassium chloride, nitrate, and sulfate tank mixed with glyphosate injured soybeans similar to glyphosate plus diammonium sulfate (DAS). Potassium chloride, nitrate, sulfate, or phosphate plus glyphosate controlled common lambsquarters, common ragweed, common waterhemp, and giant foxtail similar to glyphosate plus DAS. Other potassium sources antagonized weed control with glyphosate at the rates evaluated in this research. In a weed-free environment, soybean yield was similar among K fertilizer source treatments. Soybean treated with potassium phosphate, chloride, sulfate, or nitrate tank mixed with glyphosate had grain yields similar to glyphosate plus DAS. Potassium chloride, sulfate, and nitrate applied alone or tank mixed with glyphosate had gross margins similar to glyphosate plus DAS at the rates evaluated in this research.

COMMON LAMBSQUARTERS CONTROL WITH GLYPHOSATE. LeAnna L. Lyon, Technology Development Representative, Monsanto Agronomy Center, Monmouth, IL 61462.

With the increased awareness of glyphosate resistant weeds, complaints have surfaced over the herbicide's efficacy on several difficult to control weeds, including common lambsquarters. Many of these complaints stem from decreased control on weeds that were subjected to stress conditions immediately before or after the herbicide application. To address these concerns, studies were conducted at multiple locations across the Midwest, Central Plains, and Northeast in 2004 to evaluate alternative recommendations to control common lambsquarters under challenging conditions and to compare the efficacy of Roundup WeatherMax® and Roundup OriginalMax® to competitor glyphosate formulations.

The treatments included: Roundup WeatherMax at 0.75 lb ae/A + ammonium sulfate (AMS); Roundup WeatherMax at 0.75 lb/A; Roundup WeatherMax at 0.75 lb/A + nonionic surfactant (NIS); Roundup WeatherMax at 1.12 lb/A + AMS; Roundup OriginalMax at 0.75 lb/A + NIS + AMS; Roundup OriginalMax at 0.75 lb/A + AMS; Touchdown IQ® at 0.75 lb/A + AMS; Clearout 41 Plus® at 0.75 lb/A + AMS; Glyphomax Plus® at 0.75 lb/A + AMS; Glystar Plus® at 0.75 lb/A + AMS; and Callisto® at 0.05 lb ai/A + atrazine at 0.5 lb ai/A + crop oil concentrate (COC) + fertilizer. Ammonium sulfate, NIS, COC and fertilizer rates varied by location, but were within labeled specifications for all products.

Across the thirty locations, no differences in common lambsquarters control were observed at 7 to 14 days after treatment (DAT) when any glyphosate formulation was used and control was greater than 85% in most cases. A few locations did observe decreased control with an application of Callisto + atrazine (50 to 60%). Similar results were observed at 21 to 36 DAT across all locations. All glyphosate products controlled common lambsquarters greater than 87% while Callisto + atrazine provided around 50% control.

Generally speaking, conditions were not as challenging as anticipated; however, several trials did encounter cool or dry conditions prior to application, and common lambsquarters control was still very good. In several instances, the weeds were even over the labeled height for control, but were not stressed, so the herbicides were all effective. These data indicate that common lambsquarters, as with any weed, requires optimum growing conditions for herbicidal activity and must be managed according to the label of any product for the conditions in which the weed is growing.

EVALUATION OF GLYPHOSATE TANK-MIX PARTNERS IN GLYPHOSATE TOLERANT SOYBEAN. Kevin W. Bradley, Jimmy D. Wait, and Jianmei Li, Assistant Professor, Research Associate, and Research Specialist, Department of Agronomy, University of Missouri, Columbia, MO 65211

Field experiments were conducted at two locations in Missouri during 2004 to evaluate the effect of various glyphosate tank-mix combinations on weed control, soybean phytotoxicity, and soybean yield compared to applications of glyphosate alone. The potassium salt of glyphosate was applied alone at 0.77 lb/A or in combination with 0.004 lb thifensulfuron, 0.016 and 0.02 lb imazamox, 0.13 and 0.19 lb acifluorfen, 0.5 lb bentazon, 0.094 lb lactofen, 0.008 and 0.016 lb cloransulam, 0.004 lb chlorimuron, 0.094 lb fomesafen, and 0.006 lb flumetsulam when weed size ranged from 2 to 4 inches in height and also when weed size ranged from 6 to 8 inches in height. Greater than 90% late-season control of prickly sida, tall waterhemp, giant foxtail, Pennsylvania smartweed, and ivyleaf morningglory was observed at both locations with all herbicide treatments, regardless of application timing. Pre-harvest weed density counts and biomass were also similar among all herbicide treatments and application timings. These results indicate that the addition of either of these herbicides to glyphosate did not improve control of prickly sida, tall waterhemp, giant foxtail, Pennsylvania smartweed, or ivyleaf morningglory compared to applications of glyphosate alone, regardless of application timing. Some visual soybean injury was observed with all treatments containing acifluorfen, thifensulfuron, imazamox, lactofen, chlorimuron, and fomesafen, but this injury was transient and ranged from 1 to 5% by 21 days after treatment. At both locations, all herbicide treatments provided similar but significantly higher soybean yields than the untreated control.

COMMON DANDELION CONTROL WITH FALL AND SPRING BURNDOWN TREATMENTS.
Jerry D. Doll, Extension Weed Scientist, Department of Agronomy, University of Wisconsin, 1575 Linden Dr., Madison, WI 53706.

Wisconsin farmers often find spring burndown treatments provide less than desired dandelion control prior to no-till planting corn or soybean. Effective fall treatments would allow planting when conditions are right without waiting to first apply a spring burndown herbicide program. Trials with both fall and spring applied burndown herbicides were done for 3 years at the Arlington Agricultural Research Station. Fall applications were made on Nov. 2, 2001, Nov. 7, 2002 and Oct. 23, 2003. Spring treatments were applied on Apr. 29, 2002, May 6, 2003 and Apr. 27, 2004. The previous crop was corn in 2001/02 and 2002/03 and an old alfalfa field in 2003/04. Herbicides were applied with the recommended adjuvant(s) in 20 gal/a of water with a backpack CO_2 sprayer fitted with extended range flat fan nozzles. Dandelion control and abundance ratings were taken after application and up to fall harvest. Fall and spring burndown treatments included 0.48 lb ae/a of 2,4-D ester unless otherwise noted. Corn or soybean was no-till planted each spring and an appropriate annual weed herbicide program was used.

Fall applied treatments that consistently gave 90% or greater common dandelion control through June the next season included tribenuron (always at 2.66 gm ai/a unless otherwise noted) plus other sulfonylurea herbicides such as clorimuron, clorimuron + thifensulfuron (Synchrony) and rimsulfuron + thifensulfuron (Basis) and flumioxazin. 2,4-D ester alone and with glyphosate was less consistent in controlling common dandelion, probably because the modes of action of these herbicides are affected by the cooler temperatures of late October and early November in the upper midwest more than treatments based on sulfonylurea chemistries. In addition, applying herbicides in this chemical group provides an alternative mode of action to glyphosate in the burndown phase of no-till cropping systems.

To attempt an answer to the question of how late is too late for fall treatments, I applied tribenuron plus Synchrony on Dec. 5, 2003. The air and soil temperatures were 43 and 31 F, respectively, and dandelion plants had only a few green leaves near the center of the rosette leaves. The lowest temperature prior to Dec. 5 were 12 and 13 F on Nov. 8 and 9. Even under these conditions, common dandelion control in June 2004 was 98%, suggesting we have a wide window of opportunity for fall burndown programs based on sulfonylurea products.

Spring burndown treatments that gave 90% or more common dandelion control for at least 30 days after planting included Synchrony plus glyphosate or flumioxazin plus glyphosate. Spring-applied tribenuron with clorimuron or Synchrony gave excellent dandelion control but these are not legal treatments at this time due to the 45-day planting restriction for any crop following a tribenuron application. The use of fomesafen plus glyphosate without 2,4-D in the spring gave 100% dandelion control in 2003 and 83% in 2004 and does not have the planting delay of 7 days that results if 2,4-D ester is applied in the spring.

All trial sites at our Arlington Research Station had erect or prostrate knotweed and only treatments that included clorimuron or flumioxazin (either in the fall or spring) controlled this early germinating annual weed.

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RESPONSES OF EIGHT MARKET CLASSES OF DRY BEANS TO PREEMERGENCE APPLICATION OF LINURON. Peter H. Sikkema*, Christy Shropshire and Nader Soltani, Assistant Professor, Research Technician, and Research Associate, Ridgetown College, University of Guelph. Ridgetown, ON N0P 2C0.

There is little information on the sensitivity of dry beans to linuron. Tolerance of eight market classes of dry beans (black, brown, cranberry, kidney, otebo, pinto, white and yellow eye beans) to preemergence (PRE) applications of linuron at the rate of 2.25, and 4.5 kg a.i./ha were studied at two locations (Exeter and Ridgetown) in Ontario in 2003 and 2004.

The eight market classes differed in their responses to linuron. Black, brown, otebo, pinto, and white beans were more sensitive to the PRE application of linuron than cranberry, kidney, and yellow eye beans. The PRE application of linuron at 2.25 kg/ha caused 25, 33, 10 and 28% visual injury 14 days after emergence in black, otebo, pinto, and white beans, respectively. There was less than 5% visual injury in brown, cranberry, kidney and yellow eye beans. The PRE application of linuron at 4.5 kg/ha caused 40, 54, 30, and 49% visual injury 14 days after emergence in black, otebo, pinto, and white beans, respectively.

Linuron applied PRE at 2.25 kg/ha reduced plant height 38% in otebo beans and 31% in white beans. Linuron applied at 4.5 kg/ha reduced plant height by 43, 24, 56, 36 and 56% in black, brown, otebo, pinto, and white beans, respectively. There was no decrease in height of cranberry, kidney and yellow eye beans.

Shoot dry weight was reduced in otebo beans by 56% and in white beans by 46% at the low rate. Shoot dry weight was decreased by 74, 92, 52, 87, and 26% in black, otebo, pinto, white, and yellow eye, respectively at the high rate. There were no significant differences in the shoot dry weight of other market classes.

Linuron applied PRE at the low rate reduced yield by 42% in otebo beans and at the high rate reduced yield by 56, 74, and 61% in black, otebo, and white beans, respectively. There were no significant effects on the yield of other market classes.

This initial research indicates that there is not an adequate margin of crop safety for PRE application of linuron in black, otebo, and white beans. Additional research is needed to determine if there is an adequate margin of crop safety in brown and pinto beans. However, there is potential for the use of linuron PRE for weed management in cranberry, kidney and yellow eye beans.

MANAGEMENT OF PROTOX RESISTANT WATERHEMP IN A CORN AND SOYBEAN ROTATION. Scott E. Cully and Donald J. Porter, Syngenta Crop Protection Inc., Greensboro, NC 27419-8300.

Waterhemp is a very diverse plant species as is evidenced by the selection of biotypes resistant to ALS inhibitors, triazines, and now, protox inhibitor herbicides. Weed scientists in Kansas, Missouri, and Illinois have identified Protox resistant waterhemp biotypes. Protox resistant waterhemp plants were no longer controlled postemergence by once effective protox inhibiting herbicides such as fomesafen, acifluorfen, and lactofen. Glyphosate remains as the only option for total postemergence control of protox resistant waterhemp in soybeans. Research on other management systems in a typical corn and soybean rotation were examined for control of Protox resistant biotypes. In soybeans, as was expected, fomesafen applied postemergence as a conventional standard provided a low level of control of protox resistant waterhemp. Two-pass programs of *S*-metolachlor, or *S*-metolachlor plus metribuzin applied preemergence followed by fomesafen postemergence proved to be a good management system for conventional soybeans, however failed to consistently provide greater than 90% control of protox resistant waterhemp. Two-pass applications of *S*-metolachlor, or *S*-metolachlor plus metribuzin applied preemergence followed by glyphosate applied postemergence proved to be the most effective method of control of protox resistant waterhemp in Roundup Ready® soybeans. In corn, both a one-pass preemergence application of LUMAX™ herbicide and a two-pass program of Bicep II MAGNUM® applied preemergence followed by mesotrione plus atrazine applied postemergence provided excellent control of protox resistant waterhemp.

Sequence^{TM}: A NEW POSTEMERGENCE HERBICIDE IN ROUNDUP READY^{TM} SOYBEANS.
Adrian Moses*, Dunk Porterfield and Chuck Foresman. Research and Development Scientists and Technical Brand Manager, Syngenta Crop Protection, Greensboro, NC 27419.

Sequence^{TM} 5.5 EW herbicide is a pre-packaged mixture of *S*-metolachlor and the K^+ salt of glyphosate from Syngenta Crop Protection. Sequence is formulated as a 630 g per liter soluble liquid. Each liter of Sequence contains 270 g acid equivalent of glyphosate acid and 360 g ai S-metolachlor. Use rates range from 2.9 to 4.1 liters of product per hectare. Sequence at 2.9 l/ha delivers 1934 g acid equivalent of glyphosate acid and 2579 g active ingredient S-metolachlor.

Sequence herbicide is a broad-spectrum herbicide that provides postemergence burndown weed control with residual activity in RR Soybean. Sequence may be applied preemergence, preplant burndown, or post over the top of RR soybeans. Soybean shows excellent tolerance to Sequence. Small plot replicated trials were conducted across the U.S. during 2002 to 2004. Results showed that Sequence applied at 2.9 to 4.1 liters of product per hectare gave > 90% control of Palmer Amaranth (*Amaranthus palmeri*) and annual grasses at 30 days after application compared to <75% control with glyphosate at 1.6 liters of product per hectare. Sequence applied at 2.9 to 4.1 liters of product per hectare gave 96% control of tall waterhemp (*Amaranthus tuberculatus*) at 30 days after application compared to 86% control with Roundup Weathermax at 1.6 liters of product per hectare.

SUGARBEET VARIETY TOLERANCE TO *S*-METOLACHLOR AND DIMETHENAMID-P.

Scott L. Bollman and Christy L. Sprague, Graduate Research Assistant and Assistant Professor, Department of Crop and Soil Science, Michigan State University, East Lansing, MI 48824.

Previous research has shown that sugarbeet varieties vary in their response to preemergence and postemergence herbicide applications. Injury may reduce sugarbeet population, leaf area, yield, and sucrose content. A field trial was conducted in Saginaw, MI to evaluate the response of eleven sugarbeet varieties to *s*-metolachlor and dimethenamid-P at three application timings. *S*-metolachlor at 1.4 kg ha^{-1} and dimethenamid-P at 0.84 kg ha^{-1} were applied preemergence (PRE), and at 2-leaf, and 4-leaf sugarbeets. Sugarbeet injury (visual) and leaf area were recorded 14 days after the 4-leaf application. Sugarbeet varieties differed in their response to herbicide and application timing. All herbicide treatments resulted in at least 12% sugarbeet injury. Greatest crop injury occurred when *s*-metolachlor or dimethenamid-P was applied PRE. Injury from dimethenamid-P was greater than *s*-metolachlor at the PRE and 2-leaf applications. Sugarbeet injury from PRE *S*-metolachlor applications ranged from 21 to 67% compared with 45 to 75% injury from PRE applications of dimethenamid-P across all varieties. Reduction in sugarbeet leaf area was greatest from PRE applications of dimethenamid-P. Leaf area also was reduced from applications to 2-leaf and 4-leaf sugarbeets, however there were no differences observed between *S*-metolachlor and dimethenamid-P. Averaged across herbicide treatments, one of the eleven varieties was more tolerant, four were moderately susceptible, and six were highly susceptible to herbicide applications. The variety SX Prompt was the most tolerant variety to both *s*-metolachlor and dimethenamid-P at all application timings. Sugarbeet yield and recoverable white sugar was reduced by all herbicide applications, except dimethenamid-P at the 2-leaf application timing.

POSSIBLE STRATEGIES TO MANAGE WEEDS WITHOUT PHENMEDIPHAM/ DESMEDIPHAM IN SUGAR BEET. Darren E. Robinson and Allan S. Hamill, Assistant Professor, Ridgetown College, University of Guelph, Ridgetown, ON, N0P 2C0 and Research Scientist, Agriculture & Agri-Food Canada, Harrow, ON, N0R 1G0.

Growers currently rely strongly on phenmedipham/desmedipham to obtain acceptable weed control in sugar beet. In Ontario, this herbicide is registered as an emergency use, which must be annually reapplied for due to health concerns over isophorone in the current formulation. Since an isophorone-free formulation of this herbicide is not yet registered, growers are concerned over the potential deregistration of phenmedipham/desmedipham. Trials were initiated in 2004 at two locations in southwestern Ontario to evaluate other currently registered herbicides at different use patterns than are currently recommended, to determine whether weeds can be managed without this herbicide. Micro-rate applications of phenmedipham/desmedipham + triflusulfuron + clopyralid (125 + 4.5 + 35 g a.i. ha^{-1}) made four times during the growing season were compared to a number of treatments, including micro-rate applications of pyrazon + triflusulfuron + clopyralid (350 + 4.5 + 35 g a.i. ha^{-1}) alone or with low rates of ethofumesate (70 g a.i. ha^{-1}) in each application, or with s-metolachlor (1600 g a.i. ha^{-1}) in the second micro-rate application. The addition of ethofumesate did not cause visual injury to any treatments tested, however the addition of s-metolachlor did increase injury by 7-10%, and resulted in 3-12% stand loss. Micro-rates containing pyrazon gave 72% control of common lamb's-quarters (*Chenopodium album* L.) and redroot pigweed (*Amaranthus retroflexus* L.), compared to greater than 90% control in the phenmedipham/desmedipham micro-rate treatment. The addition of ethofumesate to the pyrazon micro-rates did not increase weed control consistently at both locations, however, the addition of s-metolachlor to the pyrazon micro-rates increased common lamb's-quarters and redroot pigweed control to greater than 90 and 85%, respectively, at 56 days after application. Weed management in sugar beet without phenmedipham/desmedipham may be possible using a micro-rate approach with pyrazon, if a safe and effective means to use them in conjunction with s-metolachlor can be determined.

KOCHIA AND COMMON LAMBSQUARTERS CONTROL IN SUGARBEET. Alan G. Dexter and John L. Luecke, Professor and Research Specialist, Plant Sciences Department, North Dakota State University and University of Minnesota, Fargo, ND 58105.

Sugarbeet growers in Minnesota and eastern North Dakota were asked on a survey to identify their worst weed in sugarbeet in 2003. Kochia was named worst weed by 46% and common lambsquarters by 18% of the respondents.

Eighteen herbicide treatments were applied to sugarbeet at seven locations in western Minnesota and eastern North Dakota in 2004 with the objective of measuring kochia and common lambsquarters control from the treatments.

Desmedipham & phenmedipham & ethofumesate at 0.08 lb/A plus triflusulfuron at 0.004 lb/A plus clopyralid at 0.03 lb/A plus clethodim at 0.03 lb/A plus methylated seed oil adjuvant at 1.5% v/v was the postemergence micro-rate treatment applied three or four times at a seven-day interval. Desmedipham & phenmedipham & ethofumesate at 0.25 (time 1)/0.33 (time 2)/0.5 (time 3) lb/A plus triflusulfuron at 0.008 lb/A plus clopyralid at 0.06 lb/A plus clethodim at 0.047 lb/A was the postemergence conventional-rate treatment applied three times without adjuvant at a seven-day interval. When the conventional-rate was applied four times, the rate of desmedipham & phenmedipham & ethofumesate was 0.25 (time 1) followed by 0.33 (time 2 through 4) lb/A: the clethodim rate was 0.03 lb/A and the other rates remained the same.

All treatments gave 98% or greater control of common lambsquarters at five of the six locations where common lambsquarters was present. However, at Morris, Minnesota, a separation among treatments was observed. The micro-rate applied three times gave only 72% control of common lambsquarters and four applications gave 79% control. Adding extra ethofumesate at 0.09 lb/A to each of four micro-rate applications gave 99% common lambsquarters control. The conventional-rate applied three or four times gave 99 to 100% control. Metamitron at 1.5 lb/A plus the micro-rate applied four times gave 100% control of common lambsquarters but sugarbeet injury also was increased from 8% with the micro-rate alone to 23% with the micro-rate plus metamitron.

Kochia control was evaluated at two locations in 2004. Nearly all plants were resistant to ALS-inhibitor herbicides. The micro-rate applied three times gave only 26% kochia control and four applications gave 48% control. The conventional-rate applied three times gave 73% kochia control and four applications gave 76% control. Preemergence ethofumesate at 3.0 lb/A followed by four micro-rate applications gave 72% kochia control. The best observed kochia control was from preemergence ethofumesate at 3.0 lb/A followed by four conventional-rate applications which gave 94% control. However, the cost of this treatment would be $270 per acre broadcast. Metamitron at 1.5 lb/A plus the micro-rate applied four times gave 85% kochia control compared to 48% from the micro-rate alone.

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USING REMOTE SENSING TO DETECT WEED INFESTATIONS IN MINT. Mary S. Gumz and Stephen C. Weller, Graduate Research Assistant and Professor, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907.

Peppermint and spearmint ("mint") are important horticultural crops in Indiana, Wisconsin, and Michigan and the Northwestern U.S. states of Oregon, Washington, Idaho, Montana and California. However, mint is a crop at risk due to competition from foreign produced mint oils and synthetic flavorings and rising production costs. Surveys of mint growers have shown that weed control is their highest input cost. Precision agriculture technology such as multispectral remote sensing and GPS-based weed mapping that allows growers to better monitor weed infestations in mint fields and develop site specific weed management techniques such as precision spraying would decrease weed control costs and increase overall weed management and profitability for this crop.

The evaluation of multispectral remote sensing in our studies has shown great potential for usefulness in site specific weed management in mint. Aerial multispectral images showing reflectance in the green, red, and near-infrared bands were compared to weed maps developed through GPS-based ground scouting. Several characteristics of mint such as a low growth habit, patchiness of weed infestations, changes in canopy architecture at the site of weed infestations, and differences in color between mint and key weed species allowed the use of remote sensing for weed detection, crop growth assessment and identification of field areas with possible production limitations due to a variety of factors. Supervised classification of multispectral images of peppermint and spearmint fields, based on ground-scouting observations, resulted in development of highly accurate maps of weed infestations. Weed patches of white cockle, giant foxtail, and mixed *Amaranthus* species were accurately identified over 90% of the time. Patches of weed free peppermint and spearmint were also identified with greater than 90% accuracy as were bare soil areas in fields where no crop or weeds were present due to low fertility, poor soil type or low water holding capacity. GIS based analysis of weed infestation locations combined with other field variables such as soil fertility and crop health will allow development of a site specific crop management system for mint. Such a system will optimize production inputs, minimize excessive applications of pesticide, reduce in-field human scouting requirements and provide growers with an efficient platform to maximize yields.

BENEFITS OF TRANSPLANTING TOMATO WITHIN ONE WEEK OF HALOSULFURON APPLICATION. Joseph G. Masabni, Fruit and Vegetable Extension Specialist, University of Kentucky Research and Education Center, Princeton, KY 42445.

Halosulfuron (Sandea 75WG) is labeled for pre- or post-transplant use in tomato, cucumber, cantaloupe, among other vegetable crops. For pre-transplant usage, the label specifies a 7 day waiting period after halosulfuron application under the plastic mulch before transplanting tomatoes. This period may be too long for growers who are busy in the spring with planting and pesticide sprays while on a race with the constantly changing climate of early spring.

Experiments were set up in 2003 and 2004 to determine whether transplanting tomato within 7 days after halosulfuron application affects tomato survivability and yields. In 2003, tomatoes were transplanted on a daily basis from day 0 through day 7 after halosulfuron application under the plastic mulch. Plant survival and height were collected in 2003. In 2004, tomatoes were set on a 2-day interval from day 0 through 10 after halosulfuron application under the plastic mulch. Plant height, visual rating, % early blight, and yields were collected in 2004.

In 2003, all tomato plants survived transplanting in halosulfuron treated soil for all days of transplanting. Plant height indicated that tomato plants transplanted early were taller than those transplanted late, only because they had more time to establish and grow in the field. There was no adverse effect to tomato plants from halosulfuron application.

In 2004, a severe infection of early blight confounded the results of herbicide applications. Still, none of the herbicide treatments including halosulfuron at 0.023 or 0.047 lb ai had any effect on plant height and visual rating. Yields were not statistically different from those of the control, when the effect of early blight was factored out.

RESPONSES OF FOUR ORNAMENTAL CROPS AND SELECTED WEEDS TO HERBICIDES.
Daniel A. Little*, Robert J. Richardson, and Bernard H. Zandstra, Graduate Assistant, Research Associate, Professor, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

A field study was conducted in 2003 and 2004 in Benton Harbor, MI to evaluate herbicides for use in four ornamental crops: Vinca (*Vinca minor)*, burning bush *(Euonymus alatus)*, creeping phlox *(Phlox subulata)*, and lily turf *(Lirope muscari)*. The weeds evaluated were common ragweed, wild buckwheat, Pennsylvania smartweed, common lambsquarters, hairy nightshade, and carpetweed. Herbicide treatments included sprayable formulations of isoxaben (1.49 kg ai/ha) plus metolachlor (2.13 kg /ha), isoxaben plus dithiopyr (0.56 kg /ha), mesotrione (0.28 kg /ha), trifloxysulfuron (0.004 kg /ha), and halosulfuron (0.07 kg /ha), and granular formulations of flumioxazin (0.42 kg /ha), oxadiazon (3.36 kg /ha), pendimethalin (2.1 kg /ha) plus oxadiazon (3.36 kg /ha), and a handweeded control. The greatest injury was observed with mesotrione at 60%, 55%, 45%, and 13% in lily turf, burning bush, creeping phlox, and vinca, respectively. Burning bush was sensitive to all herbicides (12 to 55% injury), except metolachlor, pendimethalin plus oxadiazon and flumioxazin, which resulted in less than 12% injury. Vinca was fairly tolerant of all the herbicides, with less than 3% visible injury one month after application. Ornamental plant size was not significantly different throughout the treatments. Ragweed control was 82% or greater with mesotrione, trifloxysulfuron, and halosulfuron. All herbicides evaluated, except trifloxysulfuron and halosulfuron, gave common lambsquarters control of 89% or greater. Hairy nightshade control was 92% or greater with isoxaben plus metolachlor, isoxaben plus dithiopyr, mesotrione, flumioxazin, and pendimethalin plus oxadiazon.

RIMSULFURON CARRYOVER EFFECTS IN CUCUMBER, SNAPBEAN, AND SUGARBEET.
Michael G. Particka and Bernard H. Zandstra, Research Assistant and Professor, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Rimsulfuron recently received a label for use in tomatoes. To determine the effects of rimsulfuron and other new tomato herbicides on following crops, rimsulfuron, halosulfuron, metribuzin, sulfentrazone, and sulfosulfuron were applied to tomatoes in 2002. In 2003 cucumber and snapbean were planted across plots. Cucumber was injured 60% by carryover from rimsulfuron at 0.064 lb/acre and had a reduction in biomass and fruit yield. Snapbean had 30-40% visual injury from carryover from rimsulfuron 0.25 lb/acre, halosulfuron 0.047 lb/acre, and metribuzin 0.25 lb/acre. Snapbean biomass and yield were not effected by any treatment.

In 2003 rimsulfuron, halosulfuron, sulfentrazone, flumioxazin, and metribuzin were applied to bare ground in August following wheat harvest. In the spring of 2004 cucumber, snapbean and sugarbeet were planted across plots. Flumioxazin 0.096 lb/acre caused 50% visual injury to snapbean 24 days after planting. Rimsulfuron 0.25 lb/acre, halosulfuron 0.047 and 0.094 lb/acre, and sulfentrazone 0.25 lb/acre caused 60% injury to sugarbeet. Sulfentrazone 0.25 lb/acre injured cucumber 30%. Cucumber plant biomass and total fruit weight were not affected by any treatment. Snapbean stand and fruit yield were not reduced by any treatment, but plant biomass was reduced by flumioxazin 0.096 lb/acre. Sugarbeet stand was reduced by halosulfuron 0.047 & 0.094 lb/acre, sulfentrazone 0.25 lb/acre, and rimsulfuron 0.25 lb/acre. Sugarbeet yield was reduced by halosulfuron 0.047 and 0.094 lb/acre, sulfentrazone 0.25 lb/acre, and rimsulfuron 0.064, 0.125, and 0.25 lb/acre.

NEW HERBICIDES FOR WEED CONTROL IN FRUIT TREES. Bernard H. Zandstra and Michael G. Particka, Professor and Research Assistant, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Successful fruit production requires season-long weed control. Annual and perennial weeds are controlled using a combination of preemergence and postemergence herbicides. However, most preemergence herbicides have preharvest intervals of 60 or more days, which precludes their application after June 1. Thus, orchards often have extensive weed infestations at harvest time. Experiments were conducted on apple, blueberry, cherry, and peach to compare registered and new herbicides for pre- and postemergent weed control. Diuron 3 lb/a plus glyphosate 1 lb or simazine 3 lb/a plus glyphosate 1 lb in mid spring gave about 60 days of weed suppression. Diuron 1.6 lb plus terbacil 0.8 lb plus glyphosate 1 lb gave a broader spectrum of control but no additional period of control. The addition of glyphosate helped suppress emerged perennials. Flumioxazin 0.38 lb or 0.75 lb plus glyphosate 1 lb gave good season-long control of most weeds. Sulfentrazone 0.5 lb and rimsulfuron 0.125 lb gave good season-long control of many annual weeds. Carfentrazone 0.03 lb plus glyphosate 1 lb in midseason controlled most emerged weeds. None of the herbicides injured any of the fruit crops.

EFFECT OF GIANT RAGWEED INTERFERENCE ON SWEET CORN YIELD AND QUALITY.
Martin M. Williams II and John B. Masiunas, Ecologist, Invasive Weed Management Research, United States Department of Agriculture – Agricultural Research Service, Urbana, IL 61801 and Associate Professor, Department of Natural Resources and Environmental Sciences, University of Illinois, Urbana, IL 61801.

The North Central Region produces approximately one-half of the domestic sweet corn grown for processing with generally heavy reliance on atrazine for weed control. A premise to the development of modern weed management systems is a quantitative understanding of the impact of weeds on the crop, however, this fundamental knowledge is lacking for sweet corn. The objectives were to quantify the effect of giant ragweed density on yield and identify processing quality traits affected by giant ragweed interference. At Dekalb and Urbana, IL in 2004, giant ragweed was established in sweet corn 'GH0937' at 0, 0.11, 0.32, 0.65, and 1.29 plants m^{-2}. Ears equal to or greater than 4.4 cm in maximum diameter were hand-picked and weighed approximately 21 days after pollination. Five ears per plot were randomly collected and analyzed for several processing quality traits. Losses in sweet corn yield and quality traits were related to giant ragweed density using a rectangular hyperbola equation. Compared to previous research in field corn, sweet corn yield losses due to giant ragweed interference were higher. Several processing quality traits, as measured by 5-ear samples, were affected by giant ragweed interference, including green ear (cob, kernels, silks, plus husks) mass, husked ear (cob plus kernels) mass, ear length, filled ear length, ear width at midpoint, number of kernels per row, kernel depth, and kernel mass. Kernel row number, moisture content, and total sugar content were unaffected. Depending upon the intended market, sweet corn weed management systems may need to consider the impact of weed populations on specific quality traits as opposed to green ear mass alone.

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

Numerous new sweet corn varieties are released each year. Although many herbicides are available for weed control in sweet corn, many warn that 'not all corn varieties may be tolerant' and that 'varieties should be tested before making recommendations'. Experiments were conducted in 2003 and 2004 to test labeled and non-labeled herbicides on various sweet corn cultivars. In 2004, 'Saturn' bicolor sweet corn was seeded on May 21, 2004. Various preemergence and postemergence herbicides were used to determine their toxicity on sweet corn growth, ear development and yields, in addition to their weed control potential.

(S)-dimethenamid 1 lb ai or s-dimethenamid 0.75 lb ai and halosulfuron 0.023 lb ai combination reduced growth of sweet corn by 47 days after treatment and significantly reduced corn ear size and yields by harvest. Halosulfuron 0.032 lb ai applied alone did not affect sweet corn when compared to the s-metolachlor and atrazine control plots. Flufenacet 0.77 lb applied alone with in combination with Lumax (s-metolachlor +atrazine +mesotrione premix) 2.46 lb ai had excellent control of honeyvine milkweed, common purslane, and ivyleaf morningglory and increased sweet corn yields in terms of ear numbers and weights. The high rate of Lumax 4.93 lb ai had no visible injury on sweet corn at 47 days after treatment and was more effective on cocklebur and most grasses than the lower 2.46 lb ai rate. The improved weed control resulted in better sweet corn yields but no differences in ear length or width. Foramsulfuron applied postemergence following Lumax or s-metolachlor also did not injure Saturn sweet corn and was more effective in terms of overall weed control.

INVESTIGATIONS INTO THE UTILITY OF MESOTRIONE IN MINOR CROPS.
Peter C. Forster, Thomas H. Beckett and Michael D. Johnson, Research and Development Scientists and Technical Brand Manager, Syngenta Crop Protection, Greensboro, NC 27419.

Field studies were conducted in 2004 to evaluate mesotrione potential for use in selected minor crops. The purpose of these trials was to evaluate the level of crop tolerance to mesotrione under field conditions. The rates generally evaluated were 70, 105 and 210 gai/ha, applied preemergence and postemergence. Most seeded annual vegetables evaluated were found to be intolerant to mesotrione applications. Sweet potato and horseradish transplants were severely injured. Perennial crops appear to show the most tolerance to mesotrione applications. Cranberries have exhibited excellent tolerance and Section 18's have been approved. A related species, blueberry, has also been found to be very tolerant to mesotrione. Moderate tolerance has been observed on peppermint and flax. Preliminary data suggests that asparagus and okra may have good tolerance, but additional field studies are required. Further evaluation has also been recommended for crops in the berry family, such as *Rubus* (blackberry, raspberry and loganberry), *Ribes* (current and gooseberry), *Sambucus* (elderberry) and *Vaccinium* (lingonberry).

NEW DESICCATION OPTIONS FOR POTATO. Harlene M. Hatterman-Valenti and Paul G. Mayland, Assistant Professor and Research Specialist, Plant Sciences Department, North Dakota State University, Fargo, ND 58105.

Field trials were conducted during 2003 and 2004 at the Northern Plains Potato Growers Association Irrigated Research site near Tappen, ND and at a NDSU Agriculture Experiment Station dryland site near Prosper, ND to compare potato vine desiccation and yield from recently registered desiccants and desiccant combinations to standard practices. Herbicides were applied to the middle two of four row plots with a CO2 pressurized sprayer equipped with 8002 flat fan nozzles with a spray volume of 20 GPA and a pressure of 30 psi. on August 21 and 29 at Prosper and September 4 and 12 at Tappen during 2003 and September 1, and 10, or just September 17 at Prosper during 2004. Percent leaf and stem necrosis for cultivars Russet Burbank at Tappen and Red Norland at Prosper were recorded 7, 15, and 21 days after treatment (DAT) in 2003 and 16 and 27 DAT during 2004.

Results indicated that in 2003, leaf and stem necrosis at 7 DAT for Russet Burbank was less with a single application of carfentrazone or pyraflufen compared to diquat. At 15 DAT, leaf and stem necrosis was less with repeat applications of carfentrazone or pyraflufen compared to diquat or diquat followed by carfentrazone. However, by 21 DAT leaf and stem necrosis was similar for all desiccants except the low rate of puraflufen. Russet Burbank yield comparisons indicated that the slower vine death with carfentrazone allowed bulking to continue. Total marketable yield and 6 to 12 oz. tubers were greater when carfentrazone was applied compared to diquat. French fries and chips made 6 to 8 wk following harvest and again 3 mo. after initial frying showed that the desiccants did not affect fry or chip color. Analysis of the reducing sugars on the stem and bud ends of the tubers did however show higher glucose levels on the stem end of tubers within the diquat treatment compared to untreated tubers shortly after harvest but that by 3 mo. of storage glucose levels in the stem end of tubers were similar.

Results from the dryland site during 2003 indicated that leaf necrosis at 7 DAT for Red Norland was less with a single application carfentrazone or diquat compared to glufosinate plus AMS. Stem necrosis at 7 DAT was less with a single application of carfentrazone , diquat, or glufosinate compared to glufosinate plus AMS. By 14 DAT, almost total leaf and stem necrosis occurred with all desiccants. Total marketable yield and 12 to 16 oz tubers were greater when carfentrazone, carfentrazone plus diquat, or diqual alone was applied compared to glufosinate plus AMS or glufosinate plus AMS followed by carfentrazone. Yield of 6 to 12 oz tubers was greater when carfentrazone, carfentrazone plus diquat, or diqual alone was applied compared to glufosinate plus AMS followed by carfentrazone

Results in 2004 indicated that leaf and stem desiccation 16 DAT was less with pyraflufen than carfentrazone or diquat. At 27 DAT, leaf necrosis was greater with carfentrazone or pyraflufen than diquat. A delayed application (16 d interval) of the middle and high rate of carfentrazone provided greater leaf necrosis as a single delayed application or repeat applications of diquat. Stem necrosis at 27 DAT was greater with a repeat application of carfentrazone (middle rate) compared to diquat.

UTILITY OF WINTER ANNUAL FORAGES FOR WEED SUPPRESSION. Matthew F. Jones and Kelly A. Nelson, Research Specialist and Assistant Professor, Department of Agronomy, University of Missouri, Novelty, MO 63460.

Recent research has shown that several winter annual forage species can provide good fall and winter grazing opportunities for ruminant animals in Missouri and may reduce winter annual weed populations. Research was conducted from 2000 to 2004 at Novelty, MO to evaluate the effect of soybean maturity on winter annual forage establishment, to determine the effects of no-till winter annual forage grass establishment compared to *Brassicas* species on winter annual weed suppression, and the effect of these management decisions on corn performance the following year. Pioneer 92B51, Pioneer 93B35, and Pioneer 94B01, were each planted at different dates at 432,250 seeds per hectare. Immediately following soybean harvest, 'Champion' collards, 'Purple Top' turnips, 'Marshall' annual ryegrass, or 'Forage Master' winter rye were seeded at 9, 8, 39, and 112 kg ha^{-1}, respectively. All treatments were planted to Burrus 671RR corn the following year at 71,877 seeds per hectare. In 2000 and 2002, winter rye reduced winter annual weed dry weights and had the highest forage production. However, corn grain yield was reduced 3139.9 and 1312.4 kg ha^{-1} in 2000 and 2002, respectively, compared to the non-treated control. Collards, turnips, and annual ryegrass did not affect corn grain yield the following year. In 2001 and 2003, winter annual weeds were sparse. Winter annual forage yields with winter rye were 612.4 kg ha^{-1} to 9,368.2 kg ha^{-1} greater than annual ryegrass, collards, and turnips. However, corn grain yield was reduced 226.1 kg ha^{-1} in a low yielding year (2001) and 1,865.1 kg ha^{-1} in a high yielding year (2004).

CONTROL OF LITTLE BARLEY IN WINTER WHEAT. Bryan G. Young and Ronald F. Krausz, Associate Professor and Researcher, Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901.

Little barley has become a major constraint for no-tillage systems used in winter wheat production in Illinois. Research was conducted from 2001 to 2004 to determine the most effective herbicide strategy to control little barley. The application of glyphosate or paraquat at planting provided 98% or greater control of little barley through the following spring. Sulfosulfuron, propoxycarbazone, and imazamox were applied postemergence in both the fall and spring. Sulfosulfuron provided 95% or greater control of little barley at the spring rating, regardless of application timing. The efficacy of propoxycarbazone was less consistent than sulfosulfuron with control of little barley ranging from 0 to 98%, with the greatest level of control observed from the spring applications of propoxycarbazone. Similarly, little barley control with imazamox was inconsistent across years with the greatest control (68%) observed for the spring application in 2002.

No consistent trends in wheat grain yield were significant. However, control of little barley at planting with glyphosate or paraquat did result in greater yield than fall or spring applications of the other herbicides in some instances. This research suggests that little barley emergence occurs primarily in the early fall, prior to planting wheat in this region. Since postemergence herbicides have provided inconsistent control or have label limitations to rotational crops (sulfosulfuron), the use of non-residual herbicides at wheat planting is likely the best strategy for control of little barley in no-till wheat production.

CONTROL OF VOLUNTEER WHEAT: IMPACT OF GLYPHOSATE APPLICATION TIME ON STORED SOIL MOISTURE. Randall S. Currie, Norman Klocke, and Curtis R. Thompson, Associate Professor, Full Professor and Associate Professor, Kansas State University, Garden City KS 67846

Wheat is a major weed in wheat-fallow-wheat rotations. Although much research has been done on rates and timings to kill wheat with glyphosate, little is known about the impact of these treatments on soil water storage, the main objective of the fallow period. In the winter of 2000-2001, 0.83-kg/ha applications of glyphosate were made on uniform stands of wheat in November, March, April, or May. A bare-soil control received 1.1-kg/ha applications of glyphosate as needed for a weed-free control during the winter and spring. Soil water was measured monthly in 0.3-m increments to a depth of 2.4 m for a year after initial treatment. After wheat senescence, the entire plot was maintained weed free with 1.1-kg/ha applications of glyphosate as needed. The experiment was repeated at different locations in 2001, 2002, 2003, and 2004. Between November and April, the total soil water in the 0- to 1.8-m profile was not consistently affected by when glyphosate was applied, so there was no clear trend for timing of application that would indicate reduction of evaporation or leaching losses compared with that of bare soil. The water storage of bare soil was only superior if glyphosate treatments were delayed until May or April. If glyphosate application was delayed until May, the bare-soil treatment preserved from 48.3 to 58.4 mm more soil water over the 1-year period than did plots treated in May. Water below 2.4 m was considered effectively lost to leaching. Leaching losses were not significant, were inconsistent, or were small for most treatments in most years. But in 4 of 5 years, the bare-soil treatment leached more soil water below 2.4 m than did the April applications of glyphosate. These losses were small and averaged less than 7.6 mm. When glyphosate treatment was delayed until May, leaching losses were also reduced in 4 of 5 years, and the magnitude of these reductions was doubled compared with those of April glyphosate applications. Although leaching losses were often small, November and May glyphosate applications produced greater than 17.8 mm water losses in 1 of 5 years, compared with those of bare-soil treatments. Compared with November applications, March or May glyphosate applications resulted in leaching losses greater than 17.8 mm in 1 of 5 years. This research suggests that soil-water losses to leaching or evaporation are seldom affected by delaying glyphosate applications for volunteer-wheat control until March or April. We speculate that before March, under no-till conditions, the benefits of the residue outweigh the cost of the water used to grow the volunteer wheat.

EFFECT OF UAN CONCENTRATION AND APPLICATION TIMING ON IMAZAMOX EFFICACY AND WINTER WHEAT RESPONSE. Phillip W. Stahlman, Patrick W. Geier, and Dallas E. Peterson, Professor and Assistant Scientist, Kansas State University Agricultural Research Center, Hays, KS 67601, and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Field experiments near Manhattan and Great Bend, KS during the 2003-2004 growing season determined the effects of imazamox application timing and nitrogen carrier concentration on efficacy and crop response in imidazolinone-tolerant winter wheat. Imazamox at 35 g/ha was applied with 28% urea-ammonium nitrate (UAN) at 1, 5, 10, 25, 50, or 100% v/v of the carrier, and each treatment contained nonionic surfactant (NIS) at 0.25% v/v. All treatments were applied either fall-postemergence (FPOST) or spring-postemergence (SPOST). A treatment of imazamox at 44 g/ha plus NIS and 1% UAN was included at each application timing, as was a nontreated control.

Wheat injury at Manhattan was greatest when imazamox was applied FPOST with 25, 50, or 100% UAN (9 to 12%), whereas imazamox with 1, 5, or 10% UAN in the fall caused less than 5% injury. Little or no injury was observed with SPOST treatments at Manhattan or with any treatments at Great Bend. Imazamox at 44 g/ha with 1% UAN did not injure wheat at either application timing or location. Cheat control with imazamox was 98 to 100% at Manhattan regardless of herbicide rate or UAN concentration when applied in the fall; SPOST treatments controlled cheat completely. Feral rye control was affected by UAN concentration and the interaction of location by application timing. Averaged over locations and timings, imazamox at 35 g/ha with 1 to 10% UAN concentration controlled feral rye 75 to 80% and did not differ between concentrations. Rye control was greater when imazamox was applied with 25, 50, or 100% UAN (86 to 87%). At Manhattan, rye was controlled 98 to 99% regardless of application timing. However, control was lower at Great Bend with FPOST-applied (92%) or SPOST-applied imazamox (40%). Wheat yields did not differ between imazamox rates, UAN concentrations, or application timings, and no treatment improved yields compared to nontreated wheat. Averaged over all other factors, yields were 52.8 and 70.0 bu/A at Great Bend and Manhattan, respectively.

THE INFLUENCE OF NITROGEN FERTILIZER CARRIER ON SULFOSULFURON, PROPOXYCARBAZONE, FLUCARBAZONE, AND MESOSULFURON EFFICACY. Dallas E. Peterson and Greg W. Hudec, Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506 and Technical Service Representative, Bayer CropScience, Manhattan, KS 66502.

Postemergence wheat herbicides are sometimes applied in combination with liquid nitrogen fertilizer as the spray carrier. Applying an herbicide and topdress fertilizer together saves a trip across the field and reduces production costs. However, using liquid nitrogen fertilizer as a spray carrier also can influence crop tolerance and efficacy of the herbicide. A field experiment was conducted near Manhattan, KS to evaluate weed control and winter wheat response to several postemergence herbicides applied with 0, 50, or 100% liquid nitrogen fertilizer as the spray carrier. The experiment had a randomized complete block design in a split plot arrangement with herbicide and application stage as the main plot and spray carrier as the subplot. Sulfosulfuron at 35 g/ha, propoxycarbazone at 45 g/ha, propoxycarbazone at 15 g/ha plus mesosulfuron at 10 g/ha, and flucarbazone at 30 g/ha plus chlorsulfuron at 13 g/ha plus metsulfuron at 2.5 g/ha were each applied as fall and spring treatments. All herbicide treatments included nonionic surfactant. Spray carriers consisted of water, 28% UAN fertilizer, or an equal blend of water and 28% UAN fertilizer applied at a total spray volume of 112 l/ha. Weed control and wheat injury were evaluated throughout the growing season and wheat was harvested for grain yield. Weed control generally was higher when the herbicides were applied with fertilizer carrier compared to water carrier, although the differences tended to be less with propoxycarbazone compared to the other herbicides. Initial foliar burn to wheat increased as the percent fertilizer carrier increased, regardless of herbicide treatment. However, by the end of the season, there was a carrier by treatment interaction on wheat injury. Late season wheat injury included height reduction and general stunting. Late season wheat injury generally was greater for spring applications than fall applications of the same herbicide treatment. Late season wheat injury from propoxycarbazone was not influenced by fertilizer carrier, but injury was greater with fertilizer carrier than water carrier for the other herbicides, especially for propoxycarbazone plus mesosulfuron. Wheat yields were high due to favorable growing conditions and were generally higher with herbicide treatment than from the untreated check. However, wheat yields were less where herbicides were applied in 100% UAN carrier compared to water only carrier, despite receiving more nitrogen. The lowest wheat yield occurred with the spring application of propoxycarbazone plus mesosulfuron in 100% fertilizer carrier, which corresponded to the highest late season crop injury. Application of sulfosulfuron, propoxycarbazone, or flucarbazone in 50% nitrogen fertilizer carrier solution can improve weed control with minimal risk to wheat. Application of propoxycarbazone plus mesosulfuron in nitrogen fertilizer carrier may result in excessive wheat injury.

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BROME CONTROL IN WINTER WHEAT WITH PROPOXYCARBAZONE-SODIUM (OLYMPUS HERBICIDE). George Simkins, Kevin K Watteyne, Jack D. Otta, and Shane S. Hand, Bayer CropScience RTP, NC 27709.

Olympus Herbicide is a new postemergence herbicide developed by Bayer CropScience for weed control in winter wheat. Olympus 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. Olympus Herbicide 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. Olympus Herbicide exhibits excellent winter wheat tolerance at 30 to 45 g ai /ha.

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

Olympus 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. Olympus Herbicide offers a flexible recropping profile to succeeding crops.

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.

ANNUAL RYEGRASS (*LOLIUM MULTIFLORUM* L.) CONTROL IN WINTER WHEAT WITH MESOSULFURON-METHYL (OSPREY HERBICIDE). Daren R. Bohannan, David Lamore, Michael Weber, Jack D. Otta, Kevin B. Thorsness, and S. Shane Hand. Bayer CropScience RTP, NC 27709.

Osprey Herbicide is a new postemergence herbicide developed by Bayer CropScience for weed control in winter wheat. Osprey Herbicide is comprised of the active ingredient mesosulfuron-methyl. This herbicide acts as an inhibitor of acetolactate synthase (ALS). Osprey Herbicide will control many important grass weeds in winter wheat and is highly active on wild oat and Italian/annual ryegrass as well as some broadleaf weeds such as wild mustard. Osprey Herbicide exhibits excellent winter wheat tolerance at 10 to 15 g ai /ha.

In field experiments in North America, Osprey Herbicide controlled Italian/annual ryegrass, annual bluegrass, wild oat, and canarygrass as well as wild mustard, Tansy mustard and blue mustard. Osprey Herbicide is applied to grass weeds up to 2-tiller in size and 1-2 leaf mustards. Applications of Osprey Herbicide must include a tankmix partner of either a high-quality methylated seed oil containing 10% emulsifier or greater at 1.3 to 1.5 pint/acre, a basic blend type adjuvant at a concentration of 1% v/v, or a non-ionic surfactant containing at least 80% active non-ionic surfactant at a concentration of 0.5% v/v. A nitrogen source must be used when non-ionic surfactant is used as the adjuvant system. Nitrogen should be an ammonium nitrogen fertilizer that can be either spray grade 28 to 32 percent urea ammonium nitrogen at 1 to 2 quart/acre or ammonium sulfate fertilizer at 1.5 to 3 pounds/acre.

Osprey 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 mesosulfuron-methyl in the environment. Osprey Herbicide is rapidly degraded and unlikely to pose any risk to succeeding crops. Excellent control of ACC-ase resistant wild oat (*Avena fatua* L.) biotypes has been attained with Osprey Herbicide in field trials. Osprey Herbicide also controls diclofop-resistant Italian/annual ryegrass (*Lolium multiflorum* L.).

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

USING MAIL SURVEYS TO EXPLORE NEW EXTENSION AUDIENCES. Krishona Martinson, Regional Extension Educator, University of Minnesota, Andover, MN 55304.

Surveys have been used extensively in Extension program needs assessments, however, response rate has historically been low leading to frustration and uncertainty regarding the results. The University of Minnesota conducted a state-wide survey of 1,000 Minnesota horse owners to understand the need of horse owner education in Minnesota. The survey identified key Extension program needs with a response rate of 69%. The objectives of this paper are to discuss the processes which led to the high response rate and valuable program information. The survey of Horse Owners was conducted as a mail survey in spring of 2004 with assistance from the Minnesota Center for Survey Research (MSCR) and endorsement from the Minnesota Horse Council. The initial questionnaire draft was developed by MCSR and based on questions developed by Extension faculty. The draft instrument was presented to three different focus groups. Prior to the start of data collection, changes suggested by these three groups were incorporated into the survey to create the final questionnaires. Questionnaires were sent to a random sample of Minnesota horse owners. Because no comprehensive list of Minnesota horse owners was available, horse groups and organizations were asked to share their membership and/or mailing lists. Mailing and data collection were conducted from April 2 to May 25, 2004. The first mailing was sent to horse owners on April 2, and included a cover letter inviting participation in the survey, the survey, and a self-addressed, stamped return envelope. The second mailing consisted of a reminder postcard, which was sent April 9 to all horse owners selected for the sample. On April 23, a third mailing was sent to all individuals who had not yet returned their survey. This mailing was identical procedurally to the first mailing and included a copy of the questionnaire, a reminder cover letter, and a self-addressed, stamped return envelope. Returned surveys were counted to track sample status and response rate. Peak survey returns occurred within a few days after each mailing. The survey identified the need for a state-wide horse program in Minnesota and gave insight on topics and how horse owners want to receive horse related information. The majority of horse owners responding currently obtain information from equine magazines, other horse owners, veterinarians, trainers and farriers. When asked how likely they would be to obtain horse related information, horse owners preferred short publication, the internet, and evening seminars. Saturday morning programs, on-line courses and all day Saturday programs were less desirable. The survey identified local veterinarians and feed and tack store owners as key partners needed to make a state-wide program successful. The survey data was also used to build the Horse Team. The Program Team now consists of 22 faculty members from 11 different Departments or Colleges. The survey has helped the team forge relationships with key local horse groups and secure financial contributions. In conclusion, mail surveys can be very usefully in determining needs assements in Extension programs. However, endorsement by local organizations, assistance from a professional survey center, and multiple mailings are recommended for high participant response and survey success.

INDIANA GLYPHOSATE-RESISTANT HORSEWEED (*CONYZA CANADENSIS*) SURVEY: CURRENT STATUS. Vince M. Davis*, William G. Johnson, and Kevin D. Gibson, Graduate Research Assistant, Assistant Professor, and Assistant Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Understanding the geographic distribution and frequency of glyphosate resistant horseweed (GRH) in Indiana has been a concern to soybean producers for the last couple of years. The objective of this project was to develop a field survey system in which both geographic distribution and frequency of occurrence could be determined for horseweed escapes in soybean fields. Counties were selected for sampling based upon a point system for determining which counties had the highest priority. 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.

Survey sites within a county were randomly pre-selected using maps developed from digital aerial raster imagery (orthophotos) developed by the United States Geological Service and Natural Resources Conservation Service and the Cropland Data Layer program conducted by the National Agricultural Statistical Service. Orthophotos and Cropland Data Layers 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 corn production for the 2003 and soybean production for 2004 surveys. The coordinates for the randomly selected soybean fields were downloaded to a GPS unit and a driving route was developed to facilitate efficient travel time between survey sites. A form was used at each survey site to gather information including presence and abundance of weed escapes that protruded the soybean canopy and type of field tillage system estimated by the status of crop residues present. If horseweed escapes were present at the survey site seed heads from forty plants were sampled. Since soybean was our primary crop of concern, if a pre-selected point did not fall directly in a soybean field, it was moved to the next soybean field on the diving route. The random survey system was supplemented by taking up to one additional sample between pre-selected points from soybean fields in which horseweed was 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 in pre-selected survey sites. Supplemental survey sites were not included in frequency analysis

In the fall of 2003, 792 sites were surveyed for the presence of horseweed in Indiana. Most of the survey locations were in southeast Indiana where the first populations of glyphosate-resistant horseweed were discovered. 388 horseweed samples were collected and 116 demonstrated less than 60% visual control at 21 days after the initial 1.7 kg ae/ha glyphosate screen. In the fall of 2004, 324 sites were surveyed. The geographical area sampled in 2004 was a one to two county wide band surrounding the southeastern region sampled in 2003. The counties extend east from Tippecanoe to Jay County on the eastern state line and extending south from Tippecanoe to Warrick on the southern state line in the southwestern region of the state. Of 2004 sites, 62 HW samples were collected for later herbicide screening and evaluation.

CHARACTERIZATION AND MANAGEMENT OF A HORSEWEED BIOTYPE WITH RESISTANCE TO GLYPHOSATE AND ALS-INHIBITORS. Jeff M. Stachler, Mark M. Loux, and S. K. Harrison, Weed Science Extension Program Specialist, Professor, Professor, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210.

Greenhouse and field studies were conducted in 2003 and 2004 to characterize and manage a horseweed biotype with resistance to acetolactate synthase (ALS) inhibitors and glyphosate. In 2003, initial screening of 34 horseweed populations from Ohio resulted in the identification of one population from Montgomery County with resistance to cloransulam and glyphosate. A dose response study was subsequently conducted in the greenhouse to further characterize the response of this biotype to cloransulam and glyphosate, in comparison to three other biotypes that were ALS-resistant, glyphosate-resistant, or ALS- and glyphosate-sensitive. Cloransulam and glyphosate were applied alone and in combination at rates ranging from 0.001 to 100 times the recommended rate, which was 18 and 840 g ae/ha, respectively. The R/S (resistant to sensitive) ratio for the biotypes with ALS or glyphosate resistance was 105 and 25, respectively. The R/S ratio for the biotype with multiple resistance was 47 for cloransulam, 16 for glyphosate, and 21 when treated with a combination of cloransulam and glyphosate.

A field dose response study was conducted with the multiple-resistant biotype in the spring of 2004. Cloransulam and glyphosate were applied alone and in combination at 1, 2, or 4 times the recommended rate at two stages of horseweed growth, corresponding to plant stem heights of 1 and 10 cm. Horseweed control 28 DAT (fall germination at time of application), averaged across herbicide treatments and growth stages, was 58, 66, and 79% at 1X, 2X, and 4X, respectively, and decreased to 39, 51, and 60% at 42 DAT (fall and spring germination before and after application). When averaged across herbicide rates and treatments, control 28 DAT was 70% and 66% for the 1 and 10 cm horseweed stages, respectively, and decreased to 44% and 56% at 42 DAT. At 42 DAT, 95 to 100% of the plants were ALS-resistant in cloransulam treatments. For treatments containing glyphosate or cloransulam plus glyphosate, 55 to 75% of the plants were resistant to 1X rates, and 5 to 20% of the plants were resistant to 4X rates, when averaged over horseweed growth stage.

A field study was conducted to determine proper management of this multiple resistant biotype. The study included four main treatments, glyphosate (840 g ae/ha), glyphosate (3370 g ae/ha), glyphosate (840 g ae/ha) plus cloransulam (18 g ai/ha), and paraquat (548 g ai/ha to 885 g ai/ha) plus metribuzin (420 g ai/ha). Additionally, 2,4-D ester (560 g ai/ha and 1120 g ai/ha) was included with each of these main treatments. All treatment combinations were applied to three different stages of fall-germinated horseweed plants, 1, 10, and 23 cm stem length. Control was evaluated 28 DAT and 42 DAT after last application. Fall-germinated horseweed control averaged across all herbicides was 100, 94, and 94% for the 1, 10, and 23 cm timing, respectively. However, total (fall and spring-germinated) horseweed control at 42 DAT after last treatment was 61, 90, and 91%, respectively, due to germination after herbicide treatment. Glyphosate (840 g ae/ha) plus 2,4-D ester (560 g ai/ha) applied at the 10 cm timing provided only 87% control of fall-germinated horseweed at 28 DAT while glyphosate (3370 g ae/ha) plus 2,4-D ester (1120 g ai/ha) provided 100% control. Glyphosate (840 g ae/ha), plus cloransulam (18 g ai/ha), plus 2,4-D ester (560 g ai/ha) provided 87% fall-germinated horseweed control at the 23 cm timing at 28 DAT.

Results of these studies confirmed the presence of resistance to ALS inhibitors and glyphosate in a single horseweed biotype. The level of resistance to ALS inhibitors and glyphosate in this biotype was similar to that of other biotypes that were either ALS- or glyphosate-resistant. The high rate of glyphosate (3370 g ae/ha) in combination with 2,4-D ester and application to horseweed plants 10 to 23 cm tall were necessary to provide 93 to 100% control of the glyphosate and ALS-resistant horseweed biotype.

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CONTROLLING ROUNDUP READY VOLUNTEER CORN AND SOYBEAN FOR $1/A. Richard K. Zollinger and Jerry L. Ries, Associate Professor and Research Specialist, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Replicated field research was conducted in 2004 at several locations to evaluate herbicide efficacy from reduced rates on Roundup Ready volunteer corn and soybean. Treatments were applied to volunteer corn at 20 to 24 inches tall. Clethodim (Select 2EC), from 0.5 to 1.5 oz/A gave 37% to 80% corn control. Addition of nonionic surfactant to clethodim at 0.5 oz/A improved control from 37% to 60%. However, addition of nonionic surfactant did increase control at higher clethodim rates. Clethodim (V-10137) completely controlled volunteer corn at 0.75 oz/A and higher rates without additional adjuvant added. V-10137 is a 1 lb/gal formulation and has additional adjuvants in the formulation which improves grass control over the Select formualtion. Quizalofop gave 99% corn control from 0.44 to 0.99 oz/A. It appears that lower quizalofop rates than 0.44 oz/A may kill corn 18 to 24 inches tall.

Another study was conducted where clethodim (Select 2EC and V-10137) were applied at 0.75 oz/A with glyphosate-ipa salt and glyphosate-K salt at 0.38 lb/A plus ammonium sulfate at 1 lb/A to volunteer corn 30 to 40 inches tall. Glyphosate-K salt antagonized both clethodim formulations. However, the V-10137 formulation of clethodim was able to overcome some, but not all, of the antagonism. Clethodim (Select) plus glyphosate-ipa salt and ammonium sulfate gave 52% corn control. Various adjuvants were applied to determine adjuvant enhancement of this combinations. Addition only of Destiny and Superb HC oil adjuvants enhanced control of corn greater than 86%. Nonionic surfactants, fertilizer, deposition aid, retention aids, water conditioning agents, or blends of these materials did not increase corn control over no adjuvant added. Petroleum oil adjuvants increased corn control to 73%.

Broadleaf herbicides rates to control Roundup Ready soybean were significantly reduced from labeled crop use. Soybean size at application determined degree of control at reduced herbicide rates. Dicamba, dicamba & diflufenzapyr, atrazine, flumetsulam & clopyralid, and fluroxypyr & clopralid applied to V2 to V3 stage (POST) soybean gave near complete control. 2,4-D and clopyralid & 2,4-D gave 20% to 77% control. The rate of 2,4-D, clopyralid + 2,4-D, or the lowest rate of clopyralid & fluroxypyr were not high enough to give adequate soybean control. The same herbicides applied at V4 to V6 soybean slowly exhibited phytotoxicity and did not give greater than 53% control at 14 days after application. However, by 28 days after application only treatments containing dicamba gave greater than 93% control. Soybean control from treatments containing clopyralid seems inconsistent in that the greatest control was observed from clopyralid & flumetsulam. Flumetsulam is labeled preemergence on soybean but apparently causes injury applied postemergence. 2,4-D or fluroxypyr did increase soybean control with clopyralid to the same level as flumetsulam in the earlier application but was similar to clopyralid & fluroxypyr in the later application.

Additional costs of $9.00/A will be required for the Select formulation of clethodim at 1.5 oz/A to control Roundup Ready volunteer corn. Assuming a similar cost per unit for the V-10137 formulation of clethodim, it will cost $4.00 at 0.75 oz/A of V-10137 or 0.44 oz/A of quizalofop to control Roundup Ready volunteer corn. Reduced herbicide rates may be allowed if applications are made to smaller corn. Control of Roundup Ready soybean control can be achieved at 1$/A for atrazine and clopyralid & fluroxypyr. At least $2.00/A will be required for dicamba and dicamba & diflufenzapyr, and at least $3.00/A for clopyralid & 2,4-D and flumetsulam & clopyralid.

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CONQUERING COMFREY. Jerry D. Doll, Extension Weed Scientist, Department of Agronomy, University of Wisconsin, 1575 Linden Dr., Madison, WI 53706.

Comfrey is not in the vocabulary of most weed scientists because it is relatively uncommon on farms in the midwest. The plant was introduced into gardens for medicinal purposes from settlement times and more recently some have used comfrey as a forage. The most common situation that has led to comfrey infestations in fields is the incorporation of a former garden into a field. It is also a weed in those situations where comfrey was established for forage uses. Common observation is that "once established, there forever." Comfrey seldom produces seed but has multiple taproots that readily regrow whether intact or cut into small segments. Roots were dug in the field to a 12-inch depth and planted 1 inch deep in greenhouse pots. Root segments from the upper 6 inches of roots only 0.25 inch in length generated new plants and larger segments from roots dug from 12 inches deep also produced roots and shoots. Thus, the potential for vegetative propagation is very high. Tillage both multiplies the comfrey population and prolongs its emergence period. Even without soil disturbance, plants emerge well into the growing season complicating postemergence application timings.

Trials were done in producer fields with serious comfrey infestations in Sauk Co., Wisconsin in 2001-2003. Roundup Ready (RR) corn and soybean were planted by the producers and postemergence herbicides were evaluated for comfrey control. The 2001 site was moldboard plowed prior to planting RR corn. No tillage was done in the 2002 and 2003 trials where RR corn RR soybean were planted, respectively. Plots were 400 to 600 ft^2 in size and replicated three times. Herbicides were applied in 15 to 18 gal/a of water with a CO_2 backpack sprayer fitted with extended range flat fan nozzles. Additives were used as per labeled recommendations.

Persistent rains in 2001 prevented the farmer from planting the field until the end of May. At that time, comfrey was 12 to 30 inches tall and flowering. The field was moldboard plowed on May 26 to obtain a level playing field. RR corn was planted in 38-inch rows on May 28. Postemergence herbicides were applied on July 6. Comfrey was 2 to ll inches tall and had not flowered. On July 11, the second part of split treatments was applied. Unless otherwise noted, the glyphosate rate in all years was 0.75 lb ae/a and all other herbicides were applied at normal use rates.

In 2001, dicamba alone, dicamba premixed with diflufenzopyr, and dicamba tank mixed with glyphosate gave 80% or more control of treated comfrey plants 30 days after application. The premix of primisulfuron plus dicamba, halosulfuron alone, mesotrione plus dicamba and glyphosate alone (single and sequential treatments) gave 60 to 80% control of treated plants. Clopyralid and mesotrione alone had little effect on comfrey. Due to continued emergence of comfrey after herbicide application, comfrey levels in September were greater than when treatments were applied.

In 2002, RR corn was no-till planted on May 29 following a May 16 broadcast application of paraquat (a burndown herbicide) and acetochlor (a preemergence treatment to control annual broadleaf and grass weeds). Surprisingly, paraquat had only a temporary effect on comfrey and did not "burn down" the treated plants adequately. Postemergence treatments were made when comfrey had started flowering on June 17 and again on July 2. On Oct. 10, glyphosate (1.5% v/v solution of a 3-lb ae/gallon formulation) was applied preharvest between corn rows with a backpack sprayer fitted with a single TK 3 tip. Even in a no-till system, comfrey emerged well into the growing season but less so than in 2001 when tillage is done. This year dicamba, halosulfuron, primisulfuron plus dicamba, mesotrione and 2,4-D failed to give acceptable comfrey suppression. Glyphosate at 0.75 lb ae/a in single and sequential applications and dicamba plus difluenzopyr at the highest labeled rate for corn gave 90% or more comfrey control.

Nearly all the 2002 treatments that contained glyphosate had less than 10% comfrey abundance (0-100 scale) on August 20 but only those with two glyphosate applications had less than 15% comfrey abundance at the end of the season. Comfrey control with the preharvest glyphosate application was nearly 100% when evaluated in May 2003. Sequential application of glyphosate in RR corn in 2002 also resulted in less than 10% comfrey abundance the year after application and sequential use of dicamba plus diflufenzopyr had 15% abundance, the best of all non-glyphosate-based treatments.

In 2003, RR soybeans were no-till planted on May 30. Paraquat or glyphosate with metolachlor was applied as a burndown/preemergence treatment prior to planting. We observed that preplant glyphosate noticeably reduced comfrey vigor but paraquat did not. Glyphosate applied in-crop gave 81 to 97% comfrey control in late July with only a slight advantage to sequential applications and no greater control from rates above 0.75 lb ae/a. Glyphosate was applied alone as a preharvest treatment to mature soybean on Oct. 6 and after harvest alone and in combination with either tribenuron and rimsulfuron plus thifensulfuron (Basis), or with tribenuron and clorimuron + thifensulfuron (Synchrony) on Oct. 30. In May 2004, the preharvest treatments were nearly free of comfrey (0 to 2%) and even the postharvest applications were as effective as in-crop application of glyphosate in reducing comfrey abundance.

Comfrey can be conquered. The formula for success is to 1) plan to use a no-till system and glyphosate resistant crops for two seasons, 2) plant comfrey-infested fields last to delay the burndown application of glyphosate as long as possible, 3) apply a low rate of a soil-active herbicide with the burndown treatment, 4) plant 3 days after applying the burndown treatment, 5) apply 0.75 lb ae/a of glyphosate when comfrey is well into the flowering stage (probably mid to late June) and 6) consider preharvest glyphosate applications if necessary.

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. Weed Science Educator, 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 an experimental formulation of clethodim V-10137 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 8-14 and 21-30 DAT.

At all three locations there was no significant difference between treatments when comparing the glyphosate resistant corn control. All treatments provide 90-100% control regardless of glyphosate, grass herbicide or additive. In Lincoln and Clay Center there was no difference in control of other weeds with glyphosate as well with all treatments achieving 93-100% control of amaranthus abutilon or chenopdium spp. At North Platte clethodim and fluazifop+ fenoxaprop provided significantly less kochia control when COC was used in conjunction with glyphosate mixtures. However when the COC was added to the glyphosate products without the grass herbicide there was no reduction in weed control.

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 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 volunteer corn control was typically the same whether NIS or COC was used as the additive. It appears that the addition of COC will not typically reduce glyphosate activity on other weeds.

DRIFTING ACROSS THE LANDSCAPE. Dawn E. Nordby, Michelle L. Wiesbrook, and Scott M. Bretthauer, Extension Specialist, Department of Crop Sciences, University of Illinois, Urbana, IL 61801, Extension Specialist, Department of Natural Resources and Environmental Science, University of Illinois, Urbana, IL 61801, and Extension Specialist, Department of Agricultural and Biological Engineering, Urbana, IL 61801.

Every year the number of drift problems is increasingly higher, keeping applicators, Extension specialists and educators, Illinois Dept. of Ag. inspectors, and lawyers very busy. Diagnosing crop injury from herbicides can be difficult; however, dealing with ornamentals, which may be unfamiliar, coupled with emotional land- or homeowner(s) can really be challenging. Just as weed species and crops vary in their degree of susceptibility to different herbicides, landscape and garden plants do too. Over the years, many have relied on the use of photographs of injured crop plants in identifying herbicide drift. Unfortunately, similar resources based on landscape and garden plants are quite limited. To fulfill this need, field studies were conducted during the summer of 2004 in Urbana, IL. Several species of ornamental and vegetable plants were treated with various herbicides. Rates used were 1/5- and 1/10X. Injury symptoms were observed and photographed throughout the summer. A Drift Injury In-Service was held in July to examine and diagnose injury symptoms on ornamentals and crops, review herbicide mode of action, and go through farmer/homeowner problem simulation.

Plants included:
Woody plants: Redbud (*Cercis canadensis*), Red oak (*Quercus rubra*), Black walnut (*Juglans nigra*), White pine (*Pinus strobus*), Douglas fir (*Pseudotsuga menziesii*)
Small shrubs: Dwarf lilac (*Syringa patula*), Weigela (Weigela florida), Rose (*Rosa spp*.)
Perennials: Purple coneflower (*Echinacea purpurea*), Tickseed (*Coreopsis grandiflora*), Gloriosa daisy (*Rudbeckia hirta* var. pulcherrima), Russian sage (*Perovskia atriplicifolia*), Garden mum (*Chrysanthemum* x morifolium)
Annuals: Ageratum (*Ageratum houstonianum*), Salvia (*Salvia splendens*), Marigold (*Tagetes erecta*), Petunia (*Petunia* x hybrida), Coleus (*Coleus* x hybridus).
Vegetables: Hungarian yellow wax peppers (*Capsicum annuum* L.), tomatoes (*Lycopersicon esculentum*), and pumpkins (*Cucurbita pepo* L.).

Herbicides included:
2,4-D, atrazine, chlorimuron, clopyralid, dicamba, triclopyr, 2,4-D+mecoprop+dicamba, and glyphosate.

THE SCOTTS COMPANY PERSPECTIVE ON PRODUCT DEVELOPMENT FOR SUSTAINABLE TURFGRASS. Robert W. Harriman, Vice President, Biotechnology, The Scotts Company, 14111 Scottslawn Rd., Marysville, OH 43041.

Turfgrass provides a broad spectrum of environmental and human health benefits. The Scotts Company has almost one hundred years of history developing products to assist both professional and residential turf managers. As one would expect, the number and quality of products has changed significantly over that time. With improvements in technology and increased environmental awareness, expectations are rising on product developers and university scientists to provide superior stands of grass that are also more environmentally sustainable. Scotts has focused its attention on five areas of development to provide products and information that will assist turfgrass managers with these challenging goals. While each development area will be introduced, the talk will focus on developing varieties with enhanced aesthetics that require fewer inputs and less energy to maintain.

AGRONOMIC EVALUATION OF HERBICIDE TOLERANT TURFGRASS VARIETIES.
Eric K. Nelson, Director of Turfgrass Development, The Scotts Company, 14111 Scottslawn Rd., Marysville, OH 43041.

Glyphosate tolerant bentgrasses (GTB) could provide multiple benefits to seed growers, golf course superintendents, golfers, and the environment. Performance characteristics of herbicide tolerant turfgrasses must be competitive with commercial cultivars across environments and management regimes to ensure broad market acceptance upon deregulation. Breeding, selection and testing of bentgrass germplasm used to develop GTB's was initiated prior to and concurrent with regulatory research and regulatory review by federal agencies. Multiple trial sites were established under USDA notification during each generation of variety development. GTB lines were compared to various standard cultivars including: Penncross, L-93, Providence, Penn A-4, Crenshaw and Penneagle under both putting green and fairway management. Turf quality, disease tolerance, shoot density, shade tolerance, wear tolerance and other agronomic performance characteristics were evaluated. GTB germplasm and varieties are comparable to widely accepted commercial cultivars in all performance characteristics examined. Varietal development and testing continues to enhance the performance and overall benefits of GTB for the golf course market.

USE AND TIMING OF GLYPHOSATE (ROUNDUP PRO® AND QUIKPRO™) IN TURF CONVERSION TO ROUNDUP READY® BENTGRASS. Michael B. Faust and Donald L. Suttner, Turf Specialist, The Scotts Company, Marysville, OH 43041 and Technical Lead Turf and Ornamentals, Monsanto Company, St. Louis, MO 63141-7843.

Golf course superintendents require effective turf conversion protocols that minimize the timeframe out of play to facilitate adoption of Roundup Ready bentgrass. Creeping bentgrass, perennial ryegrass and Kentucky bluegrass stands managed as golf course fairway turf were converted to Roundup Ready bentgrass in several trials conducted over multiple years. Treatments including the glyphosate based herbicides, Roundup PRO and QuikPRO were compared for their ability to rapidly convert from Crenshaw creeping bentgrass to Roundup Ready bentgrass. Conventional renovation protocols such as dazomet (Basamid®), trinexapac-ethyl (Primo® Maxx) and mechanical sod removal were also evaluated. QuikPRO applied 1 day prior to seeding combined with core aeration and vertical mowing on the day of seeding provided for the most consistent, rapid establishment of Roundup Ready bentgrass. Roundup PRO applied 1 day prior to seeding combined with mechanical treatments also led to successful establishment and was comparable to sod removal. Trinexapac-ethyl and no chemical treatment combined with mechanical treatment were unsuccessful treatments.

SULFOSULFURON FOR THE SELECTIVE REMOVAL OF CREEPING BENTGRASS (AGROSTIS STOLONIFERA) FROM KENTUCKY BLUEGRASS (POA PRATENSIS). Neal R. Hageman and Domingo C. Riego, Monsanto Company, St. Louis, MO 63141-7843 and Monsanto Company, Carmel, IN 46033-9396.

Field studies were conducted at West Lafayette, IN and Columbus, OH to characterize the performance of sulfosulfuron (Certainty™ 75 WDG) for control of creeping bentgrass and selectivity in Kentucky bluegrass. Rates of sulfosulfuron from 14 – 84 gai/ha were applied to creeping bentgrass stands at West Lafayette or Kentucky bluegrass stands infested with creeping bentgrass at Columbus. Separate crop injury studies on Kentucky bluegrass were conducted at West Lafayette. Application timing ranged from 9/18/03 to 10/30/03. Both single and sequential applications were made during this timeframe.

Single applications were unsuccessful in providing any significant control of creeping bentgrass. Triple applications as sequentials were effective in reducing populations of creeping bentgrass at both locations. Mid-Fall application timing provided highest levels of control. Late-Summer and early-Fall application timing was less successful. Higher rates of application and sequentials of higher rates showed the greatest potential for creeping bentgrass control. Injury to Kentucky bluegrass was observed with higher rates at mid-Fall application timing at evaluation in late 2003. Evaluations in Spring, 2004 indicated that Kentucky bluegrass was fully recovered from injury the previous year at both locations.

THE REGULATORY APPROVAL PROCESS FOR BIOTECH TURFGRASSES.
Terry B. Stone. Director, Biotechnology Regulatory Affairs, The Scotts Company, Marysville, OH 43065.

Three U.S. regulatory agencies have oversight for biotechnology-derived plants, the United States Department of Agriculture, the Food and Drug Administration and the Environmental Protection Agency. Since 1994, more than 60 plants have been cleared for commercialization. Glyphosate tolerant creeping bentgrass is the first biotechnology-derived perennial grass to seek regulatory clearance. The nature of the environmental risk assessment and the path to deregulation will be discussed.

OVERVIEW OF THE NATIONAL ENVIRONMENTAL POLICY ACT AND PERFORMANCE OF AN ENVIRONMENTAL IMPACT STATEMENT FOR GM PLANTS. Frederick R. Anderson, Partner, McKenna Long & Aldridge LLP, 1900 K Street, NW, Washington, DC 20006.

The Animal and Plant Health Protection Service (APHIS) of the US Department of Agriculture has decided to prepare the first-ever full Environmental Impact Statement (EIS) on a genetically modified plant product, glyphosate-tolerant creeping bentgrass (GTCB). Creeping bentgrass is already in wide use on golf courses. GTCB would greatly improve golf course management by reducing overall herbicide use and maintenance costs. EISes are required by the National Environmental Policy Act (NEPA) of 1970 on "major federal actions significantly affecting the quality of the human environment." APHIS has decided that its decision whether to deregulate GTCB under the federal Plant Protection Act, a necessary step before GTCB can be marketed, is such a major federal action. NEPA has been described both as a "full disclosure" law and a "look before you leap" law. It requires the development and disclosure of potential environmental impacts so that federal agencies make important decisions in awareness of the possible consequences of their actions. In preparing its EIS, APHIS has set out plans to conduct a fully transparent, expeditious consultative process whereby other federal agencies, state and local governments, the scientific community, and the public will have an opportunity to comment first on the scope of the EIS and then on the contents of APHIS's draft EIS. Thus NEPA includes, on the one hand, a scientific component (including analysis of alternatives to the proposed deregulation and any potential indirect or cumulative impacts of deregulation), and, on the other hand, a consultative procedural component, both of which have been spelled out in detailed agency guidelines as well as guidelines issued by the President's Council on Environmental Quality. Furthermore, the courts have played a seminal role in shaping NEPA in many hundreds of NEPA decisions. The elaborate NEPA process has led some parties whose businesses require federal decisions in order to move forward to question whether the process can ever be successfully navigated. Yet, hundreds of parties have successfully moved through the NEPA maze. To succeed, they keep firmly in mind that NEPA is, after all, only a disclosure, documentation, and consultation statute: it imposes no regulatory or other substantive standards whatsoever, and its role is limited to informing agency decision makers. Officials and companies who complete the NEPA process by the quickest and easiest path also err on the side of over compliance rather than under compliance. As early as 1971, a landmark NEPA decision made clear that the NEPA required "a strict standard of compliance," an admonition agencies are still learning to take seriously. This helps prevent and if necessary defeat lawsuits brought by groups who seek only to delay federal action or to attempt to turn the NEPA process into a media "show trial" to publicize their policy views. Such in fact is already being attempted with GTCB. Non-profit groups have filed a NEPA lawsuit on APHIS's approval of GTCB test plantings, as a vehicle to carry their anti-GMO campaign into the courts and the media.