THE ROLE OF HYBRIDIZATION IN CATTAIL (*TYPHA* SPP.) INVASIONS OF FRESHWATER WETLANDS IN GREAT LAKES NATIONAL PARKS. Steven J. Travis, Joy E. Marburger, and Steve K. Windels, Research Ecologist, USGS National Wetlands Research Center, Lafayette, LA 70506, Research Coordinator, Indiana Dunes National Lakeshore, Porter, IN 46304, and Biologist, Voyageurs National Park, International Falls, MN 56649.

In the early 1960s researchers reported that two species of cattail, the native *T. latifolia* (broadleaf cattail) and the European *Typha angustifolia* (narrowleaf cattail), hybridized in North America. The resulting hybrid was classified as *T.* X *glauca*. More recently modern molecular techniques permit analysis of the degree of hybridization locally and regionally to evaluate its effect on native wetland biodiversity. Species-diagnostic RAPD (randomly amplified polymorphic DNA) markers were used to identify pure *T. latifolia* and *T. angustifolia* so that individuals of these species could be used to identify diagnostic microsatellite makers for a subsequent analysis of genetic admixture within individuals exhibiting hybrid ancestry. We examined the prevalence of hybrids in three Great Lakes national parks representing multiple habitat types, and the relationship between clone size and hybrid status in newly invaded areas. Samples from nine East Coast sites from Virginia to Connecticut were also evaluated. Intensive sampling of 150 individuals from each of five sites was conducted during 2004, with a less intensive, broader survey of 20-40 individuals from each of 20 sites (including Isle Royale National Park) conducted during 2005. Results from the 2004 samples showed a history of hybridization within all sites, with a few pure *T. angustifolia* populations at St. Croix National Scenic Riverway and Voyageurs National Park. Individuals sampled at Indiana Dunes National Lakeshore and St. Croix showed evidence of backcrossing to *T. angustifolia*, whereas those at Voyageurs were more similar to *T. latifolia.* A higher incidence of first-generation hybrids was also apparent at Voyageurs, suggesting that *T. angustifolia* has reached this park most recently. The lack of pure *T. latifolia* in these samples suggests it may be at risk of extirpation from portions of its former range.

VARIATION IN SOIL BIOFEEDBACKS ASSOCIATED WITH MICROSTEGIUM VIMINEUM.
Jeremy R. Klass and Scott J. Meiners, Department of Biological Sciences, Eastern Illinois University, Charleston, IL 61920

A wide range of biotic and abiotic factors have been shown to impact the structure and dynamics of plant communities. However, much of this research has focused on the importance of abiotic factors, particularly light and soil nutrients, and has ignored the biotic component of soils. Despite this focus on abiotic constraints, accumulating evidence has identified soil biota as having a potentially important role on invasion biology and plant populations. Soil biofeedbacks are generated by a diversity of organisms and the resulting soil community can serve as a form of density-dependant regulation and may play an important role in maintaining the diversity of terrestrial plant communities. The mechanisms involved in the biofeedback of a particular site, comprising the indirect effects, are established and assist in regulating community assemblages and dynamics along with invasions, and successional trajectories.

With particular interest in the soil-feedback effects on interspecific competition, we are hypothesizing that *Microstegium vimineum,* an exotic C4 grass, has created a negative feedback through the soil community on the understory forest flora within the Buell Small Succession Study (BSS), effecting population dynamics and community structure of the system.

To address the research question, we conducted a greenhouse soil inoculum experiment utilizing an associated understory species in order to determine whether the mechanism responsible for the impacts observed by the *Microstegium* invasion within the BSS is related it*'s* ability to alter the soil community. Our sample design allows us to observe local variation among individual soil communities that are replicated in 10 adjacent fields comprising the entire site. We also took soil samples from an adjacent old growth forest that borders the BSS to determine variability in soil biofeedbacks. At the end of the growing period, plants were harvested and total above ground biomass was determined.

We found no overall effects of *Microstegium* on plant performance and only a status effect (live vs. autoclaved soil). However, the comparison of individual fields yielded variation within the site where some fields experienced a status effect, a *Microstegium* effect or an interaction between status and *Microstegium.* Reproductive success was found to be most strongly correlated with biomass, and therefore, plants that performed better had the highest probability of flowering.

In most soil biofeedback studies, samples are pooled over the entire site leading to a sample that may be unrepresentative of local, spatially explicit soil communities that can play an integral role in plant community assemblages. The most important aspect yielded by this experiment is when considering soil feedback studies, variation can exist in systems that cover the same landscape and can vary significantly from overall site effects. We argue that variation can be easily over-looked when the spatial aspect of a system is not considered or ignored and should be included in further soil feedback studies

NATIVE AND EXOTIC SPECIES EXHIBIT SIMILAR POPULATION DYNAMICS IN SECONDARY SUCCESSION. Scott J. Meiners, Jeremy R. Klass and Timothy A. Rye, Department of Biological Sciences, Eastern Illinois University, Charleston, IL 61920-3099.

Exotic species are often thought to have traits that confer an advantage over native taxa. However, it has rarely been tested whether native and exotic species exhibit different population dynamics, which would be predicted if exotic invaders were on average superior to native residents. We described the population dynamics of 84 native and exotic plant species during succession using data from the Buell-Small Succession Study. For each species we quantified 12 population parameters that described the rate of spread and decline, time and magnitude of population peak, and period of dominance. Overall, exotic species peaked earlier and were dominant for shorter periods than natives. However, this was largely driven by the abundance of annual and biennial exotics within the community. A PCA of the population characteristics revealed no distinct separation between native and exotic taxa, but found clear differences among life forms (trees, shrubs, perennials etc.). One potential exception is the exotic shrub multifora rose (*Rosa multiflora*). This was the only exotic shrub with sufficient abundance to analyze and it exhibited much greater growth rates and cover than any native shrub. Similarly, cover and frequency of the native eastern redcedar (*Juniperus virginiana*) increased faster than any other tree species. These analyses suggest that although there may be individual species with unique characteristics and population dynamics, native and exotic taxa as a whole do not behave differently within communities. The similarity of population dynamics within most life forms argues that native and exotic taxa utilize similar strategies that constrain them to similar ecological roles.

INVASIVE PLANT MANAGEMENT: BENEFITS OF A MULTIDISCIPLINARY RISK ANALYSIS APPROACH. Mark A. Tucker, Doug Doohan, Neal Hooker, and Jeff LeJeune, Associate Professor, Agricultural Communication, Purdue University, West Lafayette, IN 47907, Associate Professor, Department of Horticulture and Crop Science, Ohio State University, Wooster, OH 44691, Associate Professor, Department of Agricultural, Environmental, and Development Economics, Ohio State University, Columbus, OH 43210, and Assistant Professor, Food Animal Health Research Program, Ohio State University, Wooster, OH 44691.

Producer adoption of technological innovations such as improved seed stock and labor-saving practices is one of the major reasons for the ascendancy of U.S. agriculture over the last century. Promoted and diffused by mass media and agricultural experts, these innovations elevated agricultural productivity to record levels and transformed the food and farm sector. The theoretical diffusion model used to guide agricultural extension and communication efforts during this period continues to be widely used in the social sciences and throughout agriculture. Despite its successes, the model is not well-suited to encouraging producer adoption of practices required to contain or eliminate the spread of invasive plant species. Encouraging producers to adopt management practices to curb the spread of invasives has proven difficult because such practices are often not perceived by producers as necessary and most do not offer short-term economic advantages. These circumstances serve as barriers to the development of effective education and communication campaigns to encourage effective management of invasive plants. This poster outlines a risk-based multidisciplinary approach to adapt the traditional diffusion model to the unique challenges of helping manage invasive plants that threaten agricultural productivity and profitability.

INVASIVE MANAGEMENT STRATEGIES AT PENINSULA STATE PARK. Kathleen A. Harris, Park Naturalist, Wisconsin Department of Natural Resources, Peninsula State Park, PO Box 218, Fish Creek, WI 54212.

Peninsula State Park, established in 1909, has managed vegetation since its beginning. In 1916 for instance, 95,000 trees arrived for planting, and in 1935 the Civilian Conservation Corps cleared over 200 acres of poison ivy near the beach. Emphasis on invasive species accelerated in the 1990s. In 2000, the park naturalist developed Peninsula's first Invasive Species Management Plan (IMP). It is reviewed biannually. Specific objectives are listed and prioritized each year.

Peninsula's IMP includes goals that articulate ideal conditions at specific geographic sites. For example, "The Peninsula shoreline is free of purple loosesrife (*Lythrum salicaria*) and non-native phragmites (*Phragmites communis*)." However, given current staffing and a limited pool of able-bodied, trained volunteers, achieving ideal conditions in this 3,700-acre park is an enormous undertaking. Conservation targets act as a reality check.

Conservation targets identify Peninsula's most ecologically unique areas. Since many invasive species thrive at Peninsula State Park, the IMP identifies species that can most damage the ecological integrity of conservation targets. Conservation targets are crucial to defining management objectives (tasks). Peninsula's conservation targets include the Niagara Escarpment, Weborg Sedge Meadow and ancient shorelines that harbor colonies of federally threatened Dwarf Lake Iris (*Iris lacustris*).

Management objectives specify location and are measurable, such as "Pull all second year garlic mustard below Sven's Bluff by June 1." The park naturalist, consulting with the superintendent, prioritizes objectives each year. Educational objectives, listed separately, may or may not address conservation targets. They do, however, consider stewardship and fostering understanding of invasive species ecology fundamental. For example "The park naturalist or intern will conduct weekly Weed Warrior programs in May and June." Weed Warrior programs, geared towards children, take place at sites devoid of rare species. Another objective that emphasizes education but has resulted in limited containment of garlic mustard involves asking every May/June camper to pull garlic mustard at his or her campsite. This effort is beginning to show results at specific sites.

Peninsula staff review objectives each year and record what was – or wasn't – accomplished. Most often, objectives are not accomplished because of a shortage of staff and funds. Occasionally, sudden Department initiatives supersede objectives. In 2006, for example, the Department implemented management efforts related to the emerald ash borer (*Agrilus planipennis*). In any case, after the review a record of management efforts exists, enabling the park naturalist to negotiate staffing and/or management needs based on numbers.

Peninsula State Park offers 479 campsites and welcomes over one million visitors each year. Containing invasive threats is an overwhelming and relentless task. Peninsula's IMP makes the challenge more manageable.

NEW INVADERS WATCH PROGRAM: AN EARLY DETECTION AND RAPID RESPONSE NETWORK TO LIMIT THE SPREAD OF NEW INVASIVE EXOTIC SPECIES IN THE CHICAGO WILDERNESS REGION

Debbie Maurer, Restoration Ecologist, Lake County Forest Preserves, Grayslake, IL 60030,
R. Edward DeWalt, Associate Research Scientist, Illinois Natural History Survey, Champaign, IL 61820, and Karen Tharp, Volunteer Stewardship Coordinator, The Nature Conservancy, Ullin, IL 62992

Early detection of new exotic invasive species and rapid response to eradicate or contain populations is an important strategy for preventing the loss of biodiversity in the Chicago Region. The New Invaders Watch Program provides the necessary tools for an effective early detection program, including: volunteer training programs, species identification cards, standardized data collection protocol, an online database and reporting system, voucher verification by herbarium staff, a Rapid Response Network, and resources to assist partners in monitoring and control efforts. In 2006, program partners reported and controlled several target species populations, including Giant Hogweed (*Heracleum mantegazzianum*) in Lake County, IL, roadside populations of Leafy Spurge (*Euphorbia esula*), Japanese Knotweed (*Polygonum cuspidatum*) in Lake Michigan ravines, and Silky Bush Clover (*Lespedeza cuneata*) in an Illinois State Natural Area. Future work includes the addition of new target species, including aquatic plants, completion of an automated alert system for the Rapid Response Network, development of an interactive online mapping module, and expansion of this early detection model to other regions in Illinois.

SURVIVAL OF CREEPING BENTGRASS AND KENTUCKY BLUEGRASS ON DEFUNCT GOLF COURSES. John C. Stier, Associate Professor, Univ. Wisconsin, Madison, WI, John N. Rogers, III, Professor, Tim VanLoo and Alex Kowalewski, Graduate Research Assistants, Michigan State Univ., East Lansing, MI.

Less than 12 grass species are used as turfgrasses in the northern part of the U.S. To qualify as turf, they share the ability to maintain a perennial, contiguous groundcover under routine mowing and traffic. Fertilization and irrigation are typically used to develop desirable turf quality. Most if not all of the cool-season turf species have Eurasian origins, having been brought to the U.S. during the colonial period as livestock fodder. Most to all commonly used cool-season turfgrasses consequently appear on various invasive species listings developed by non-governmental and governmental agencies though science-based studies of invasiveness are lacking. Two of the most commonly used cool-season grasses which appear most frequently on lists of invasive or potentially invasive species are creeping bentgrass (*Agrostis stolonifera* L.) and Kentucky bluegrass (*Poa pratensis* L.). On golf courses, putting greens are virtually always planted to creeping bentgrass while Kentucky bluegrass (KBG) is often used for fairways. Both species grow best in sunny areas. KBG prefers moist, well-drained fertile soils with pH approximately 6.0-7.0. CBG is best adapted to moist, fertile soils with slightly acid to acid pH.

Since it is often impractical to observe development of natural infestations of such plants over time to determine their invasiveness, we surveyed vegetative cover on two defunct Michigan golf courses during summer 2005. Four Winds Golf Course in East Lansing was a 9-hole course that became defunct in 2003. The site was a former wetland area surrounded by paved roads and residential housing. Putting greens were constructed of a sand-based root zone mix while the rest of the course had the native organic soil characteristic of wetlands. The 18-hole Matheson Greens Golf Course outside of Northport in northern Michigan was constructed in 1990 and managed as a golf course through 2000 when its owner stopped maintaining it in order to establish a nature preserve. The area surrounding the course was forest with some streams and wetlands. The soil type was sand to loamy sand; putting greens were apparently developed using the same soil type as the rest of the golf course. CBG was used for putting greens on both courses while fairways were seeded to KBG and fine fescues (*Festuca* spp.) were planted in the primary roughs. Four transects, all originating from the apparent center of the putting greens and at right angles to one another, were established using measuring tape and GPS coordinates. A 1 x 1.5 m frame was placed on the ground along each transect at 3, 9, 18, 36, 52, 72, and 90 m distances from the putting green center. Relative abundance of vegetation types or bare soil/other (including moss, dead/disintegrating sod, leaf litter, etc.) were ranked on a scale of 0 to 5. A 0 rank indicated none was visible, 1 = 1-5% coverage, 2 = 5-25% coverage, 3 = 25-50% coverage, 4 = 50-75% coverage, and 5 = 75-100% coverage. Types of vegetative groups were CBG, KBG, fine fescues, other grasses, herbaceous dicots, and woody species. Data at similar distances along each transect (e.g., 3 m) from a single hole were averaged for each golf course. Holes were considered as completely randomized replicates. Means were analyzed by ANOVA to identify significant differences among each turfgrass type relative to other vegetation or bare soil.

At Four Winds GC putting greens were dominated by 1+ m tall thistles and asters while CBG comprised less than 50% of the living ground cover. KBG was the dominant vegetation off the putting greens but did not necessarily form uniform swards, as other species occurred including maple saplings (*Acer* spp.). Fescues were observed at similar or lesser amounts than dicots in former rough areas. CBG, KBG and fine fescues were practically absent from Matheson Greens with most of the surface bare soil or covered by dicot species. The two sites represented extreme soil type and conditions for the Upper Midwest. Data indicate CBG, KBG and fine fescues did not compete well with other plants, primarily dicots, within two years after management practices ceased. Information is still needed on medium-textured soils across a broader range of ecosystems.

2006 North Central Weed Science Society Proceedings 61:14.

BIOLOGICAL CONTROL OF INVASIVE PLANTS IN MINNESOTA. Monika A. Chandler and Luke C. Skinner, Weed Integrated Pest Management Program, Minnesota Department of Agriculture, St. Paul, MN 55101 and Invasive Species Program, Minnesota Department of Natural Resources, St. Paul, MN 55155

Biological control, the use of natural enemies to control non-native pests, can be an effective tool in managing invasive plants. Non-native plants can become invasive because they lack the insects and diseases that control them in their native environments. Biological control reunites natural enemies, such as herbivores and pathogens, with their host (invasive plant) to reduce impacts caused by the pest. Frequently, this involves the use of specialized insects that were tested extensively for host specificity (safety) and efficacy. The goal of biological control is not to eradicate the invasive plant, but to reduce its impact to an acceptable level. The Minnesota Departments of Agriculture and Natural Resources have implemented successful biological control programs for leafy spurge, spotted knapweed, and purple loosestrife statewide. Development of new biological control efforts for garlic mustard and buckthorn are underway.

IMPACTS OF THE INVASIVE ANNUAL GRASS *MICROSTEGIUM VIMINEUM* (JAPANESE STILTGRASS) ON NATIVE TREES AND HERBACEOUS SPECIES: SOME PRELIMINARY RESULTS. S. Luke Flory and Keith Clay, Indiana University, 1001 East 3rd Street, Bloomington, IN 47405.

Invasions of non-native plant species have often been correlated with major alterations in the biodiversity, structure, and function of native ecosystems. However, studies that experimentally manipulate invasions are needed to clarify the specific negative effects of exotic plant invasions. The purpose of this study is to determine if invasion by the exotic annual grass *Microstegium vimineum* (Japanese stiltgrass) reduces the germination, growth, and survival of native trees and herbaceous species.

Invasions of *Microstegium* are an increasing threat to eastern deciduous forests. First documented in Tennessee in 1918, *Microstegium* is currently found in at least 22 states in eastern North America and is listed as a noxious weed in two states. *Microstegium* is a highly shade tolerant C_4 annual grass that produces up to a thousand seeds per plant. When it invades it creates near monospecific stands that are highly resistant to recolonization by native species.

This experiment was designed to answer the following specific questions: 1) What are the effects of *Microstegium* invasion on tree seed germination and subsequent seedling survival and growth?; 2) What are the effects of *Microstegium* invasion on 2-year old tree sapling survival and growth?; and 3) How does *Microstegium* invasion affect the diversity and abundance of native herbaceous species? This experiment can also be used to answer questions about the potential effect of *Microstegium* on forest community composition by ranking the relative impact of invasion on survival and growth among species. If there are effects of *Microstegium* invasion on native tree survival and growth, forest succession may be slowed or stopped. In addition, differences among the nine tree species would suggest that invasions of *Microstegium* can change the composition of forest communities. Finally, there could be analogous effects on native herbaceous species such that invaded areas have lower total numbers of native plants or decreased diversity.

In October of 2005, thirty-two 5.25m x 5.25m research plots were established 2.5m apart at the Indiana University Bayles Road Botany Experimental Field north of Bloomington, Indiana. Plots were located in an old field that had been dominated by *Poa pratensis, Lolium arundinaceum,* and various old field weeds for at least the previous 20 years. Late in 2005, seeds of nine species of native trees were planted in 16 plots. The five large-seeded species were planted on a 12 x 12 grid with 0.4m between each seed. The smaller seeded species were sown haphazardly throughout the plots. A mixture of 12 species of native grasses, sedges, and forbs, together with a cover crop of winter wheat, was sown into all plots. In the early spring of 2006, four 2-year old seedlings of each of the 9 species of trees were planted in a 6 x 6 grid 0.75m apart in the other 16 plots. Half of all tree seed plots and half of the sapling plots were seeded with *Microstegium* in late fall 2005.

To evaluate the impacts of *Microstegium* invasion, a destructive harvest was conducted in September 2006 by removing all of the herbaceous vegetation from eight 30 cm x 30 cm quadrats within each plot. The plants were sorted to species, dried, and weighed to determine the impact of invasion on productivity, diversity, dominance, and species richness. Trees that had been sown into the plots were counted within the quadrats and in an additional 20 cm outside the quadrats for a total of two square meters of sampling area per plot. Preliminary analysis of the data indicates that invasion by *Microstegium* reduced tree survival after one growing season by more than 20%. *Acer negundo* (box elder), *Platanus occidentalis* (sycamore), and *Liriodendron tulipifera* (tulip poplar) were negatively affected by invasion while *Liquidambar styraciflua* (sweetgum) and *Fraxinus pennsylvanica* (green ash) had equal survival between invaded and uninvaded plots. Analysis of effects of invasion on herbaceous vegetation is ongoing. Future work will include determining seedling survival of sown and planted seeds, sapling survival and growth, and effects on herbaceous species each year through 2008.

2006 North Central Weed Science Society Proceedings 61:16.

THE ROLE OF WEED MANAGEMENT ON A MULTI-PARCEL PRAIRIE RESTORATION SITE WITHIN AN URBAN SETTING. Heidi Zajack, Melanie Oetzman, and Brian John Brezinski, Undergraduate Student - Applied Science Program, University of Wisconsin-Stout, Menomonie, WI 54751-0790, Conservation Project Specialist and Grazing Lands Specialist, River Country Resource Conservation and Development Council, Inc., Altoona, WI 54720.

In the fall of 2005, a group of non-profit organizations and businesses in the Chippewa River Valley area formed the Prairie Partnership, a collaborative partnership with the goal of developing a 51 acre corridor of remnant prairie owned by Xcel Energy, Inc. The Prairie Partnership is interested in developing these remnants into an urban green space and an outdoor classroom, providing environmental education and stewardship opportunities for the community.

Since its inception, the Prairie Partnership has been successful in acquiring grants to allow a 501(c)3 non-profit, River Country Resource Conservation and Development Council (RC&D) Inc., to coordinate the Prairie Partnership, and carry out the Partnership's goals. Xcel Energy Inc. has approved the Partnership to begin restoration and environmental education projects on the remnant prairie.

In the spring of 2006, River Country RC&D and the Prairie Partnership sent out over 1,000 informational brochures to the community about the Prairie Partnership, and held 7 educational outreach events on the remnant prairie. Monthly field surveys were conducted from June through September of 2006 to aid in the formation of a management plan. The remnant prairie was divided into 10 sites, varying in size from 2 to 10 acres. Each site was inventoried to determine its relative quality, and restoration capability.

A management plan is being developed to help determine the capacity for restoration on each of the 10 designated sites. In addition, this plan will develop a framework for incorporating environmental education and community outreach into each phase of the restoration process.

NCWSS WEED CONTEST 2006. Jess J. Spotanski, Midwest Research Inc., York, NE 68467.

The 2006 NCWSS summer annual Weed Contest was hosted by Midwest Research Inc. in York, Nebraska on July 26th and 27th. There were a total of 41 students from seven schools. The schools were Purdue University, Ohio State University, University of Missouri, Kansas State University, Parkland College, Iowa State University and North Dakota State University. Of the students who participated, there were 16 graduate students and 25 undergraduates. Volunteer support was excellent as 40 people from both industry and academia braved the high heat and humidity to make the contest a success. The contest was made up of the traditional four events which were farmer problem solving, sprayer calibration, weed identification and unknown herbicide identification. A total of 22 awards were handed out to the highest scoring teams and individuals in both graduate and undergraduate divisions. The overall graduate team award winners were: 1st-Purdue, 2nd-Missouri, 3rd-Kansas State. The overall undergraduate team award winners were: 1st-Ohio State Team 1, 2nd-Ohio State Team 2, 3rd-Parkland College. The overall graduate individuals were: 1st-Nick Monnig, Missouri, 2nd-Andy Westhoven, Purdue, 3rd-Michael Duff, Kansas State. The overall undergraduate award winners were: 1st-Jason Parrish, Ohio State, 2nd-John MacMillan, Purdue, 3rd-Valerie Mock, Purdue. The individual events and winners were: Team field calibration: Missouri-graduate and Ohio State Team 1-undergraduate; Written calibration individual: Sara Krippner-North Dakota State-graduate and Jason Parrish-Ohio State-undergraduate; Unknown herbicide individual: Nick Monnig-Missouri-graduate and Jason Parrish-Ohio State-undergraduate; Weed identification individual: Andy Westhoven-Purdue-graduate and Jason Parrish-Ohio State-undergraduate; Farmer problem solving individual: Greg Kruger-Purdue-graduate and John MacMillan-Purdue-undergraduate. Thanks to all the volunteers who helped with the contest and congratulations to all the winners.

IMPACT OF CHLORPYRIFOS APPLICATION TIMING ON HERBICIDE RESPONSE IN STS VS NON-STS SOYBEANS. Marsha J. Martin, Mick F. Holm and Gregory R. Armel. Development Representative, Columbus, OH 43235, Development Representative, Waunakee, WS 53597 and Product Development Specialist, Newark, DE 19714. DuPont Crop Protection.

Synchrony® XP is a premix of chlorimuron-ethyl plus thifensulfuron-methyl at a 3.1:1 ratio used for preplant, preemergence, or postemergence control of several broadleaf weeds in soybeans. Chlorpyrifos is an organophosphate insecticide that is used to control many insects including soybean aphids (*Aphis glycines*) which has become a pest of growing concern in many soybean producing regions. Currently, Synchrony® XP can not be applied in mixtures with organophosphate insecticides like chlorpyrifos because of increased potential for crop response. However, based on previous research, Synchrony® XP can be safely applied 14 days before or after an organophosphate application in soybeans. Since several varieties of glyphosate tolerant soybeans now contain stacked resistance to sulfonylurea herbicides (sulfonylurea tolerant soybeans- STS™ soybeans), the question was whether this STS™ trait would afford improved crop tolerance with chlorpyrifos plus Synchrony® XP mixtures or more importantly whether STS™ soybeans would allow for greater flexibility when it comes to making separate applications of Synchrony® XP and chlorpyrifos to soybeans in the same growing season.

Studies were conducted in 2006 at 8 locations in Iowa, Illinois, Michigan, Minnesota, Ohio, and Wisconsin to evaluate Synchrony® XP (7.5 and 15 g ai/ha) alone and in mixtures or sequential applications with chlorpyrifos at 1120 g ai/ha (7 and 14 days before and after chlorpyrifos applications) on both STS™ and non-STS™ soybeans. Glyphosate was applied, as needed, to help maintain weed free conditions.

As expected, mixtures of Synchrony® XP plus chlorpyrifos caused significant response (53-61%) on non-STS™ soybeans and this response was significantly greater than responses observed with either material applied alone. Crop response from these mixtures was still prevalent at 56 days after treatment. When following label recommendations requiring chlorpyrifos applications either 14 days before or after Synchrony® XP on non-STS™ soybeans, crop response was similar to when Synchrony® XP was applied alone without any additional insecticide applications. However, when mixtures of chlorpyrifos plus Synchrony® XP were applied to STS™ soybeans these mixtures only caused 6 to 8% crop response after 7 days. In addition, the four sequential application timings for Synchrony® XP before or after chlorpyrifos applications averaged less than 7% response on STS™ soybeans after 7 days. By 14 days after treatment, the tank mix and sequential applications on STS™ soybeans were at less than 2.5% injury compared to 0% injury from the materials alone. All crop response observed on STS™ soybeans was considered transient as it dissipated entirely by 28 days after treatment.

SEED QUALITY DYNAMICS OF SOYBEAN GROWN UNDER COMPETITION.
Katherine D. Millar, Bryan G. Young, David J. Gibson, and Andrew J. Wood, Graduate Research Assistant, Associate Professor, Professor, and Professor, Department of Plant Biology and Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901.

It is well known that increasing weed competition adversely affects soybean yield; however there is a lack of information regarding how weed competition alters seed oil and protein. A two-year field experiment investigated the impact of competition on seed quality for five soybean cultivars (Asgrow 4603, Asgrow 4403, and Asgrow 3903, Forrest, and Essex). The different cultivars were planted under three levels of competition, which were established through application of the pre-emergence herbicides, s-metolachlor and cloransulam, at three different rates. Weed competition impacted seed protein (2004) and seed oil (2005). Seed oil and protein were measured using NIR spectroscopy. Seed protein increased (between 0.7 and 1%) and seed oil decreased (between 0.29 and 0.5 %) under the most intense competition. There were cultivar differences with respect to oil and protein production, but interaction of cultivar and weed competition was evident for seed protein content in 2005. The Essex cultivar produced the greatest protein and the lowest oil content across both years. Asgrow 4403 produced the highest oil amongst all cultivars both years, but produced seed protein content similar to the other Asgrow varieties. Total seed yield was also measured and decreased under increasing weed competition. This study indicates the importance of biotic stress on seed production and quality and future studies should investigate the mechanism whereby seed quality is altered under competition.

TRIBENURON-TOLERANT SUNFLOWER PRODUCTION: SEED AND HERBICIDE SYSTEM UPDATE. Lawrence S. Tapia, James D. Harbour and Craig Alford, Product Development Manager and Field Development Representatives, DuPont Ag & Nutrition, Denver, CO, 80228.

Tribenuron-tolerant sunflowers were developed by Pioneer in the early 1990's by traditional plant breeding methods. A single, dominant gene confers resistance to tribenuron, and this gene has been incorporated into key elite germplasm. Field research was conducted in KS, TX, SD, ND, NE, CO, and IL from 2002 to 2006 to determine efficacy, crop response and yield comparisons when tribenuron was applied to 2-leaf (V2), 8-leaf (V8), and post-bud (R1) tribenuron-tolerant sunflower. Standard small-plot research techniques were used at all the research locations each year. Tribenuron was applied, at 0.125, 0.1875, 0.25, 0.5 or 1.0 oz ai/a to either V2, V8 or R1 tribenuron-toltrant sunflowers; and in some tests, each herbicide rate was applied sequentially to V2 then V8, growth-stage sunflower.

Phytotoxicity at 7 DAT ranged from 0 to 22% and decreased to less than 5% at 40+ DAT. Phytotoxicity was generally greater when tribenuron was applied to V2 or V2 then V8 sunflower (2 – 22%) than V8 or R1 sunflower (<1%). However, tribenuron-tolerant sunflower injury decreased to 4% or less by 40+ DAT. Tribenuron controlled common lambsquarters and marshelder regardless of herbicide rate, herbicide program or application timing; however, common purslane was not controlled by tribenuron. Kochia, palmer amaranth, redroot pigweed, Russian thistle, and puncturevine were controlled best with tribenuron applied sequentially to V2 then V8 sunflowers.

Field research was conducted to determine efficacy and tribenuron-tolerant sunflower response to various weed control programs currently used in the US. Pendimethalin, sonalan, and sulfentrazone were applied pre-emergence to tribenuron-tolerant sunflower, after which tribenuron (0.125 oz ai/a) was applied post-emergence to approximately V8 sunflower. Further, tribenuron (post-emergence) was applied without a pre-emergent herbicide for a POST-only herbicide treatment program. Phytotoxicity was less than 4% (14 DAA) regardless of herbicide treatment program. Weed control programs provided good-to-excellent control of Kochia, Russian thistle, and puncturevine.

Yield comparisons of improved tribenuron-tolerant sunflower lines were conducted in 2006 with tribenuron at 1X, 2X and 4X use rates. There were no sunflower yield differences with tribenuron applied at 1X and 2X rates compared to a comparable sunflower herbicide and seed program. Tribenuron applied at 4X tribenuron use rates resulted in unacceptable yield loss for several lines tested.

RESPONSE OF CORN TREATED AT TWO GROWTH STAGES WITH FOLIAR - APPLIED HERBICIDES. James R. Martin and Charles R. Tutt, Extension Professor and Research Specialist, Department of Plant and Soil Sciences, University of Kentucky, Princeton, KY 42445.

Delaying postemergence treatments to allow time for late emerging warm-season weeds to reach optimum stage may cause growers to apply overtop corn that exceeds the V6 growth stage. This practice has sometimes led to crop injury, particularly with certain Acetolactate Synthase (ALS) inhibitor herbicides. The labels of many of the ALS inhibitor herbicides indicate to not apply them as broadcast sprays overtop corn that exceeds the V6 growth stage.

Studies were conducted in 2005 and 2006 to evaluate and compare various postemergence herbicides for their potential to cause crop injury when applied to corn at either V4 or V7 growth stages. Corn was planted on April 11 both years using conventional tillage practices. The 2005 study had isolines with similar base genetics, yet different herbicide tolerant traits. ‘Garst 8451 RR’ was used for evaluating glyphosate and sulfonylurea herbicides; whereas, ‘Garst 8450 IT’ was used for evaluating the premix of imazethapyr plus imazethapyr as well as the non-treated check. The imidazolinone herbicides were not included in the 2006 study, consequently the only hybrid used in the second study was ‘Dekalb DKC63-74 RR2/YGPL’. Soil - residual herbicides were used to maintain a weed - free environment.

Treatments were applied to V4 corn on May 13, 2005 and May 6, 2006; and to V7 corn on May 31, 2005 and May 26, 2006. Plants were hand harvested from an area of 50 ft^2 within the two center rows to determine grain yield and to evaluate for ear abnormalities.

The postemergence herbicides compared in both years were nicosulfuron at 0.5 oz ai/A, foramsulfuron at 0.53 oz ai/A, premix of nicosulfuron at 0.38 oz ai/A plus rimsulfuron at 0.19 oz ai/A, and glyphosate at 0.75 lb ae/A. The premix of imazethapyr at 0.67 oz ai/A plus imazapyr at 0.22 oz ai/A was evaluated only in 2005 and rimsulfuron at 0.25 oz ai/A was evaluated only in 2006. Adjuvants were included with the herbicides according to label directions.

Corn plants in all treatments in the 2005 study had normal vegetative growth throughout the season. However, in the 2006 study, injury in the form of stunted plants and shortened internodes were observed when the premix of nicosulfuron plus rimsulfuron or rimsulfuron alone were applied to corn in the V7 growth stage. As much as 13% injury was observed at five weeks after applying the premix to corn in the V7 growth stage.

Abnormal ears in the form of twisted rows or pinched areas were observed in all treatments, including the non-treated check, both years. The amount of abnormal ears for the premix of nicosulfuron plus rimsulfuron applied to corn in the V7 growth stage was 40% in 2005 and 20% in 2006. These values exceeded those observed in non-treated checks in both studies. Rimsulfuron applied at the V7 stage was the only other treatment that had a significant percent of abnormal corn ears relative to the non-treated checks in the 2006 study.

Delaying application until V7 growth stage tended to influence corn grain yield of some treatments. The yield reductions in the 2005 study were less obvious than those in the 2006 study and were not statistically different for any of the treatments. However there was a trend for low yield when the premix of nicosulfuron plus rimsulfuron was applied to V7 corn. There were significant yield reductions in the 2006 study. The yield of premix of nicosulfuron plus rimsulfuron was 167.6 bu/A compared with 227 bu /A for the non-treated check. Applying rimsulfuron alone at V7 resulted in 39.3 bu/A less yield than that of the non-treated check in the 2006 study.

The results of this research show that foliar - applied herbicides may differ in their potential to injure corn when applied to plants that exceed the recommended growth stage. The herbicides that had the highest risk to cause abnormal ears when applied at V7 growth stage included the premix of nicosulfuron plus rimsulfuron and rimsulfuron alone.

CONTROL OF COCKLEBUR IN SOYBEAN. Nader Soltani, Chris Kramer, Joshua Vyn, and Peter H. Sikkema, Research Associate, Research Assistant, Research Technician, and Associate Professor, University of Guelph Ridgetown Campus, Ridgetown, ON, Canada.

Field trials were conducted in 2006 on three Ontario farms with heavy infestations of cocklebur to determine the effectiveness of various PRE- and POST-emergence herbicides for the control of cocklebur in soybean. There was no injury to soybean at 7, 14, and 28 DAE from any of the PRE-emergence and POST-emergence herbicides evaluated. Cloransulam-methyl applied PRE provided 96% visual control, reduced density 87%, and reduced dry weight of cocklebur 98%. Flumetsulam applied PRE provided 71% visual control, reduced density 56%, and reduced dry weight of cocklebur 81%. Linuron, metribuzin, imazethapyr, and clomazone applied PRE provided little (15-49%) visual control and reduced density and dry weight of cocklebur minimally (50% or less) compared to the weedy check. Cloransulam-methyl applied POST provided 89% visual control, reduced density 83%, and reduced dry weight of cocklebur 99%. Chlorimuron-ethyl, imazethapyr, imazethapyr plus bentazon, and glyphosate applied POST provided 72-79% visual control, reduced density 60-77%, and reduced dry weight of cocklebur 90-98%. Acifluorfen, fomesafen, bentazon, and thifensulfuron-methyl applied POST provided 14-34% visual control, reduced density 0-47%, and reduced dry weight 0-86% compared to the weedy check. Based on these results, cloransulam-methyl applied PRE or POST-emergence provides excellent control of cocklebur in soybean. Flumetsulam applied PRE and chlorimuron-ethyl, imazethapyr, imazethapyr plus bentazon, and glyphosate applied POST have some potential for cocklebur control in soybean. Linuron, metribuzin, imazethapyr, and clomazone applied PRE and acifluorfen, fomesafen, bentazon, and thifensulfuron-methyl applied POST do not provide adequate control of cocklebur in soybean at the rates evaluated.

CLOPYRALID TOLERANCE OF CUPHEA. Sharon Papiernik, Frank Forcella, Russ Gesch and Gary Amundson. North Central Soil Conservation Research Laboratory, USDA-Agricultural Research Service, Morris, MN 56267.

A new oilseed crop known as cuphea (*Cuphea viscosissima* x *lanceolata*) is an annual plant that is planted in spring. It is adapted well to the northern portions of the Corn Belt of North America. Unfortunately, cuphea grows quite slowly until mid summer, which means that it does not compete well with spring-germinating weeds. Previous research on herbicide tolerance indicated that soil-applied ethalfluralin, isoxaflutole, and trifluralin can be used effectively in cuphea, as can postemergence applications of mesotrione and grass herbicides (sethoxydim, clethodim, etc.). However, these herbicides have a limited spectrum of efficacy, especially for weeds in the Compositae, namely biennial wormwood (*Artemisia biennis*) and Canada thistle (*Cirsium arvense*). Such weeds are common in areas where cuphea is adapted. Consequently, a number of other herbicides with known activities on these weeds were explored for tolerance by cuphea. Field tests in Minnesota showed that cuphea was unaffected by clopyralid at rates typically applied postemergence to corn and small grain crops. Clopyralid also could be used safely in conjunction with soil-applied isoxaflutole. A related herbicide, aminopyralid, was not tolerated as well by cuphea. These results expand the weed spectrum under which cuphea can be grown effectively.

PERFORMANCE OF A NICOSULFURON PLUS THIFENSULFURON PREMIX IN FIELD CORN.
Susan K. Rick, Helen A. Flanigan and Gregory R. Armel, Field Development Representatives and Product Development Specialist, DuPont Ag and Nutrition, Wilmington, DE 19880.

Field studies were conducted in 2006 by university and DuPont personnel to evaluate a pre-package mixture of nicosulfuron plus thifensulfuron at a 13.5:1 ratio (Stout™ herbicide) for broad-spectrum weed control in field corn. The nicosulfuron plus thifensulfuron pre-package mixture was evaluated at 25 and 38 g ai/ha alone and in combinations with various tank mix partners in both two pass and total postemergence programs. Other herbicides evaluated in these two pass and/or total postemergence programs included isoxaflutole, rimsulfuron, mesotrione, topramezone, atrazine, metolachlor, metolachlor plus atrazine, mesotrione plus atrazine plus metolachlor, pendimethalin, dicamba, dicamba plus diflufenzopyr, and fluroxypyr.

Crop response was considered minor and transient with two pass programs containing preemergence applications of metolachlor 535 g ai/ha or metolachlor 672 g ai/ha plus atrazine 868 g ai/ha followed by nicosulfuron plus thifensulfuron alone or in tank mixtures. In general, most two pass programs containing preemergence metolachlor at 672 g ai/ha plus atrazine 868 g ai/ha followed by the nicosulfuron plus thifensulfuron pre-package mixture at 25 g ai/ah provided broad-spectrum season long control of most grass and broadleaf weeds. The addition of atrazine at 1.12 kg ai/ha, mesotrione at 53 g ai/ha plus atrazine 560 g ai/ha, or dicamba 77 g ai/ha plus diflufenzopyr at 30 g ai/ha as a postemergence tank mix partner with the nicosulfuron plus thifensulfuron pre-package mix provided improved control of giant ragweed, common waterhemp, and common sunflower in these programs. Increasing the rate of the nicosulfuron plus thifensulfuron pre-package mix to 38 g ai/ha improved the control of broadleaf signalgrass.

Little to no crop response (0 to 3%) was observed in our studies evaluating total postemergence herbicide treatments with the nicosulfuron plus thifensulfuron pre-package mix. In general, most annual grasses were controlled with 25 g ai/ha of the nicosulfuron plus thifensulfuron pre-package mixture, however the 38 g ai/ha rate provided improved control of woolly cupgrass and johnsongrass. In addition, the nicosulfuron plus thifensulfuron pre-package mix applied alone at 25 g ai/ha provided greater than 80% control of the broadleaf weeds velvetleaf, hophornbeam copperleaf, redroot pigweed, common lambsquarters, jimsonweed, ivyleaf morningglory, entireleaf morningglory, pitted morningglory, Pennsylvania smartweed, Palmer amaranth, and field pennycress. Tank mixtures of nicosulfuron plus thifensulfuron with either atrazine at 1.12 to 2.24 kg ai/ha, mesotrione 53 g ai/ha plus atrazine 560 g ai/ha, mesotrione at 73 to 75 g ai/ha plus atrazine at 280 to 568 g ai/ha plus metolachlor at 568 to 750 g ai/ha, topramezone at 18 g ai/ha, topramezone at 18 g ai/ha plus atrazine 560 g ai/ha, and dicamba 77 g ai/ha plus diflufenzopyr at 30 g ai/ha provided improved control of tall waterhemp, common ragweed, cutleaf morningglory, Palmer amaranth, and Eastern black nightshade in comparison to nicosulfuron plus thifensulfuron applied alone.

EFFECT OF INTEGRATED HERBICIDE MANAGEMENT STRATEGIES ON SOYBEAN YIELD.

Micheal D.K. Owen, Palle Pedersen, Gregory L. Tylka, Damian D. Franzenburg*, Gregory D. Gebhart, James F. Lux, Christopher C. Marett, and Jodee M. Roland, Professors and Agricultural Specialists, Department of Agronomy, Iowa State University, Ames, IA 50011.

Experiments were conducted on grower fields at 10 Iowa locations in 2004, 2005 and 2006 to determine the effects of application method for two postemergence herbicides on crop injury and soybean yield. Locations varied in tillage regime (from no tillage to reduced tillage), soybean variety, and row spacing, none of which were treatment factors. Experiments were planted in row spacing ranging from 18 to 76 cm. Each experiment was a randomized complete block with six replications. Plots were 12.3 by 12.3 m in 2004 but reduced to 6.2 by 12.3 m in 2005 and 2006. Treatments included application timings of early postemergence (EPOST) at V2 soybean, mid-postemergence (MPOST) at V4 to V6, and late-postemergence (LPOST) at R1 to R2. Sequential timings of EPOST plus MPOST and EPOST plus LPOST were also included as treatments. Herbicides included glyphosate and acifluorfen. Half of the treatments included glyphosate applied alone at each application timing (EPOST and sequentially at 0.23 kg ae ha^{-1}), and the remaining treatments included glyphosate (0.23 kg ae ha^{-1} at each application) plus acifluorfen (0.42 kg ai ha^{-1} EPOST and 0.14 kg ai ha^{-1} when applied sequentially) in each application. Weed counts were taken prior to the first application of each treatment. Visual crop injury was evaluated at 7 and 14 days after (DAA) the initial application if not followed by a sequential application. Otherwise, injury was evaluated for the last application of a treatment.

The presence of weeds in this research did not affect soybean yield. The most commonly observed weeds were giant foxtail, velvetleaf, common waterhemp, common lambsquarters and horseweed. All treatments provided excellent control of all weeds. Weed densities, as enumerated before herbicide applications, were only significantly different between treatments during 2005 and 2006. Treatment differences for 2005 were attributed to self-thinning of weeds during the time between EPOST and MPOST treatments, as smaller numbers were observed as the application timing was delayed. Patchy, heavy weed densities at the Ames location accounted for differences in 2006. Notably, there were no weed density differences between treatments in 2004 and when data was combined for all three years. Weed densities, overall, were not high enough to impact yield when their removal was delayed to the LPOST timing. The LPOST glyphosate treatment, which caused only 2% injury (averaged over all years), provided yields as high as any EPOST or MPOST treatment.

Since all soybean varieties included in the ten locations were glyphosate-resistant varieties, glyphosate injury did not exceed 5%. Injury from glyphosate/acifluorfen treatments ranged from 11 to 32%, depending on application timing. Single applications generally demonstrated lower levels of injury compared to split applications. EPOST/MPOST and EPOST/LPOST treatments with glyphosate/acifluorfen caused higher injury than MPOST and LPOST treatments, respectively.

Soybean yield did not vary by more than 471 kg ha^{-1}, which was the greatest difference among treatments for all three years. Application timing had a greater effect on soybean yield than the severity of herbicide injury. LPOST glyphosate/acifluorfen caused half as much observed soybean injury as EPOST glyphosate/acifluorfen, yet yielded significantly less in 2004 and when data was combined for all three years. Yield was reduced when acifluorfen was applied LPOST, though observed injury did not appear to be severe on R1 to R2 soybean.

ECONOMIC BENEFITS OF PREPLANT HERBICIDE APPLICATIONS IN CORN AND SOYBEAN. Gail L. Marik and Gregory R. Armel, Field Sales Agronomist and Product Development Specialist, DuPont Ag and Nutrition, Wilmington, DE 19880.

The presence of certain winter annual weed species has increased in several corn (*Zea mays*) and soybean (*Glycine max*) growing regions largely because of increasing conservation tillage acres coupled with reduced reliance on residual herbicides due in part to the advent of genetically modified crops. Attempts to control these winter annual weeds with continued use of herbicides targeting only one site of action has caused the selection of certain herbicide resistant biotypes or shifts toward increased populations of naturally tolerant weeds. Often times these resistant or tolerant weed shifts are isolated to specific tracks of land and are only considered an issue for those who use that land. However, there are certain over-wintering weeds such as dandelion (*Taraxacum officinale*), cressleaf groundsel (*Senecio glabellus*), and marestail (*Conyza canadensis*) that produce wind disseminated seeds which have the potential to spread herbicide tolerant or resistant biotypes over great distances. Therefore, the need to properly manage certain winter annual weeds will become more important if these resistant or tolerant biotypes continue to spread. Successful management strategies for these winter annual weeds include the use of fall and/or early spring applications of herbicides with various sites of action. Herbicide mixtures including certain systemic, residual herbicides like sulfonylureas in mixtures with auxin mimic herbicides (i.e. 2,4-D) and/or non-selective herbicides (i.e. glyphosate and paraquat) offer the ability to control emerged winter annual weeds with the added potential of controlling secondary germinations which could appear before crop planting. This paper will look at the potential benefits associated with these types of fall and early spring burndown applications including resistance management, improvements in seedbed condition at planting, decrease in early season weed competition, improved weed management flexibility, and a potential decrease in input costs in comparison to other alternative measures.

COMPARISONS OF RESIDUAL AND NON-RESIDUAL HERBICIDE PROGRAMS FOR WEED CONTROL AND CROP YIELD. Dawn E. Nordby and Aaron G. Hager, Extension Specialist and Assistant Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

A broad weed control spectrum coupled with relatively low herbicide cost has contributed to the widespread adoption of glyphosate-resistant soybean. However, the same characteristics that resulted in such widespread utilization of glyphosate may hasten its demise as an effective tool for weed management. Additionally, the flexibility of application and lack of residual weed control often result in farmers delaying an initial glyphosate application beyond when weed interference has caused soybean yield loss. Several soil-residual herbicides remain effective on potentially glyphosate-resistant weed species. Utilization of these types of herbicide may potentially reduce the likelihood of crop yield loss when farmers delay the application of a postemergence herbicide. Field studies were conducted in 2005 and 2006 at three locations in Illinois to compare glyphosate and non-glyphosate weed control programs in corn and soybean. Weed control programs, comprised of two or more individual treatments, were grouped into the following categories: preemergence alone, preemergence followed by non-residual postemergence, preemergence followed by a residual postemergence, residual postemergence alone, non-residual postemergence alone, a weedy check and a weed-free control.

Soybean yield in the non-residual postemergence alone herbicide program was similar to that of the weed free, 3267 and 3600 kg ha^{-1}, respectively. However, weed biomass in the non-residual postemergence alone program, 120 g m^{-2}, was not similar to the weed free. All other herbicide programs resulted in soybean yields less than 2600 kg ha^{-1}. Weed biomass in these herbicide programs decreased from 995 g m^{-2} in the weedy check to 676, 500, 314, and 262 g m^{-2} in the preemergence alone, residual postemergence alone, preemergence followed by non-residual postemergence, and preemergence followed by residual postemergence programs, respectively. Two individual treatments that provided yield and weed biomass similar to the weed free included the postemergence alone (two-pass glyphosate) and the preemergence followed by non-residual postemergence (chlorimuron+metribuzin f/b glyphosate).

Corn yield was similar to the weed free, 11,013 kg ha^{-1}, for all herbicide programs except for the preemergence alone (9644 kg ha^{-1}) and weedy check (2675 kg ha^{-1}). Weed biomass differed by herbicide program. Weed biomass was similar to the weed free in all programs except the preemergence alone (612 g m^{-2}) and preemergence followed by residual postemergence (202 g m^{-2}).

Results of this research indicate that total postemergence weed management programs in corn and soybean can be successful at preserving crop yield while reducing weed biomass when herbicide applications are timely. Preemergence alone programs did not preserve crop yield and were weedy, likely due to inadequate rainfall and lack of late-season weed control.

ADSORPTION AND DEGRADATION OF MESOTRIONE IN FOUR SOILS. Dale Shaner, Galen Brunk, Scott Nissen and Phil Westra, Plant Physiologist, USDA-ARS. Fort Collins, CO 80526, and Research Associate, Professor and Professor, Bioagriculatural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523

The adsorption and fate of mesotrione was studied in four diverse soil types varying in pH, organic matter (OM), and texture. The adsorption of mesotrione to each soil was determined using a batch equilibrium method. OM and soil pH were the most significant component of mesotrione adsorption. As soil pH increased, mesotrione adsorption decreased. The rate of dissipation of mesotrione in the plant available soil water (PAW) and soil matrix was determined for all four soils. Mesotrione decomposed rapidly in PAW of a soil with high pH (pH 7.4) whereas there was no decomposition in PAW in an acidic soil (pH 5.2). Degradation of mesotrione was significantly reduced or eliminated in PAW when soils were sterilized by irradiation. Overall, the extent of adsorption is dependent on soil OM while degradation is driven by soil microbes. Soil pH also has a major impact on the ultimate fate of mesotrione. Mesotrione degraded rapidly in a low OM, pH 7.4 soil, but was stable in a low OM, pH 5.2 soil. Chemical degradation becomes more significant in high pH soils.

PREEMERGENCE HERBICIDES TO MANAGE EARLY-SEASON WEED COMPETITION IN CORN. Timothy L. Trower, Chris M. Boerboom, and Joseph D. Bollman, Senior Outreach Specialist, Professor, and Graduate Student, University of Wisconsin, Madison, WI 53706.

Planned postemergence herbicide programs in corn have an inherent risk because early-season weed competition may reduce grain yields if early emerging weeds are not managed. Field studies were conducted at Arlington, WI in 2005 and 2006 to determine the efficacy of reduced rates of preemergence herbicides at managing early season weed growth in field corn. Selected preemergence herbicides were applied alone or followed with glyphosate. A nontreated control and glyphosate-only treatment were included as controls. Acetochlor at 1.1 kg ai ha^{-1}, atrazine at 0.84 kg ai ha^{-1}, flufenacet at 0.35 kg ai ha^{-1}, isoxaflutole at 40 g ai ha^{-1}, pendimethalin at 0.67 kg ai ha^{-1}, s-metolachlor at 0.85 kg ai ha^{-1}, and mesotrione plus s-metolachlor at 0.11 plus 1.1 kg ai ha^{-1} were applied after planting glyphosate-resistant corn. Two 0.25 m^2 permanent quadrats were established in each 3 by 8 m plot. Weed density and height were counted and measured at near weekly intervals, except that the isoxaflutole treatment was not recorded in 2005. When average weed height reached 13 cm, glyphosate was applied postemergence at 0.84 kg ae ha^{-1} in the designated treatments. Corn was harvested for yield and grain was adjusted to 15.5% moisture. The study had a randomized complete block design with four replications.

Giant foxtail and common lambsquarters were the dominant weed species in the studies. All of the preemergence herbicides reduced the density and height of at least one of the weed species in both years at the time glyphosate was applied. Atrazine was the least effective in reducing giant foxtail density compared to the nontreated control, averaging a 46% reduction in 2005 and no reduction in density in 2006. Acetochlor controlled 100% of the giant foxtail in 2005 while s-metolachlor reduced foxtail density by 98% in 2006. Atrazine in both years and pendimethalin in 2006 reduced giant foxtail height the least compared to the nontreated control. In 2005, s-metolachlor plus mesotrione reduced giant foxtail plant height the most in the treatments in which giant foxtail survived while s-metolachlor reduced height the most in 2006. S-metolachlor plus mesotrione and atrazine in both years and isoxaflutole in 2006 controlled 100% of the common lambsquarters. S-metolachlor reduced common lambsquarters density the least in both years with 26% and 83% reductions. Of the treatments with surviving common lambsquarters, acetochlor and pendimethalin reduced plant height the most at 80% and s-metolachlor reduced height the least at 20% in 2005. Acetochlor, s-metolachlor, pendimethalin, and flufenacet all reduced plant height by 33% in 2006.

All preemergence herbicides yielded more than the nontreated control in both years. The nontreated controls yielded 3,760 kg ha^{-1} in 2005 and 3,130 kg ha^{-1} in 2006. In 2005, yields with preemergence herbicides ranged from a low of 5,960 kg ha^{-1} with s-metolachlor to a high of 12,290 kg ha^{-1} with s-metolachlor plus mesotrione. In 2006, yields ranged from a low of 6,080 kg ha^{-1} with pendimethalin to a high of 12,610 kg ha^{-1} with s-metolachlor plus mesotrione. The yield increase attributed to the sequential glyphosate application varied by year. In 2005, three of seven sequential treatments yielded more than the respective preemergence herbicide alone. However, six of seven sequential treatments increased the yield compared to the preemergence herbicide applied alone in 2006. Yield differences between the sequential herbicide programs and the single postemergence glyphosate application were mixed. Four of seven sequential programs yielded more than the single glyphosate application in 2005 while only two of seven treatments yielded more in 2006.

Giant foxtail and common lambsquarters were effectively controlled with reduced rates of select preemergence herbicides due to their weed spectrum. Consequently, these preemergence herbicides reduced early-season weed competition and often provided corn yields greater than when glyphosate was applied alone. The reduced early-season competition resulted from a combination of reduced weed density and height. This suppression may allow postemergence herbicides to be applied over a longer time period while minimizing risk.

LIGHT QUALITY EFFECTS ON CORN GROWTH, DEVELOPMENT, AND YIELD. Melinda K. Markham and David E. Stoltenberg, Graduate Research Assistant and Professor, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

Recent research results have suggested that early-season detection of neighboring plants via light quality signals may be an important mechanism affecting crop-weed interactions. The increased reflection of far-red light among higher densities of green plants can lower the red:far-red ratio (R:FR) of horizontally propagated light before there is a significant degree of mutual plant shading. In turn, this modifies the light environment of stem tissue, and elicits changes in stem elongation rate. Consequently, carbon allocation patterns can be altered before photosynthesis is reduced by shading. Typical effects of reduced R:FR are enhanced axis (stem or shoot) elongation, reduced branching of broadleaves, and reduced tillering of grasses. Numerous studies conducted in controlled environments, and to a lesser extent in the field, have shown plant morphological changes associated with altered R:FR light environments. However, little research has been conducted to investigate the possible effects of R:FR-mediated alterations in weed and crop morphology on competitive outcomes under field conditions. Limited evidence suggests that altered light quality can influence early growth and development of corn, but it is not understood how responses to early-season low R:FR (associated with higher total plant densities in corn-weed communities than in weed-free corn) affect season-long growth and productivity of corn. Therefore, field experiments were conducted in 2005 and 2006 to determine the effect of low R:FR on early-season corn growth and morphology, and late-season outcomes such as corn plant biomass and grain yield. Corn 'DKC50-20RR/YGCB' was planted at medium and high densities (53,800 and 107,600 plants ha^{-1}, respectively) to establish medium and low early-season R:FR environments, respectively. The medium density treatment represented a typical weed-free corn environment, whereas the high density treatment simulated a competitive corn-weed community. The high density treatment was thinned to the medium plant density at the time of mutual shading (V6-7 corn) which simulated total weed removal. Spectral light quality (R:FR, 645:735 nm) was measured at least twice weekly from corn emergence to the time of mutual shading among plants in each treatment. Photosynthetically active radiation was measured daily to determine the time of mutual shading. The R:FR was nearly 50% less at the time of mutual shading in the high density corn treatment (0.24) than the medium density treatment (0.43). Measurements of soil moisture availability, soil nutrient availability, and corn leaf tissue nutrient status indicated that soil moisture and nutrient availability were not limiting and did not differ among light quality environments. In 2005, early-season low R:FR had little effect on corn plant morphology at the time of mutual shading. In contrast, low R:FR was associated with taller plants, longer leaves, and less tiller mass than corn plants in medium R:FR in 2006. The root:shoot ratio did not differ between light quality environments at the time of mutual shading in either year. At physiological maturity, above-ground plant biomass and corn grain yield did not differ between early-season light quality environments ($p > 0.05$). These results suggest that early-season light quality effects on corn morphology, if any, were transitory and did not affect corn yield. We conclude that early-season low R:FR typically associated with corn-weed communities was not a key determinant of corn yield in the field environment when water and nutrients were not limiting factors.

HERBICIDE EFFICACY AND FORAGE QUALITY OF SPRING-SEEDED GLYPHOSATE-RESISTANT ALFALFA. Daniel K. Tiedemann, Bryan G. Young, Ronald F. Krausz, and Joseph L. Mathews, Undergraduate Research Assistant, Associate Professor, and Researchers, Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901.

Glyphosate-resistant alfalfa may provide the opportunity for more effective control of problem weed species during the crop establishment year and potentially improved alfalfa forage quality from the absence of weeds. Alfalfa seeded in the spring is typically the most challenging for weed management since this coincides with the onset of summer annual weed emergence. A field study was conducted near Belleville, IL to evaluate the use of glyphosate for crop response, weed control, yield and quality of glyphosate-resistant alfalfa planted in the spring compared with standard herbicide treatments. Herbicides treatments included single and sequential applications of glyphosate, trifluralin, trifluralin followed by glyphosate, imazethapyr, and imazethapyr plus glyphosate.

No visual injury or reductions in alfalfa plant density were observed for any herbicide treatment. Glyphosate provided 98% or greater control of fall panicum, yellow foxtail, common lambsquarters, common waterhemp, eastern black nightshade, and yellow nutsedge regardless of herbicide rate or the number of applications. Weed control from glyphosate was more consistent across evaluation timings compared with the standard treatments of trifluralin and imazethapyr. Even though the standard treatments contained greater amounts of weeds in the forage at the first and second harvest, herbicide treatments did not influence alfalfa yield. At the first harvest, alfalfa from plots treated with trifluralin alone was lower in crude protein (CP) and relative feed value (RFV) than plots treated with glyphosate. At the second harvest no differences were evident in the CP and RFV between the herbicide treatments. This research suggests the use of glyphosate in glyphosate-resistant alfalfa may improve weed control compared with standard herbicide treatments. However, alfalfa yield was not increased with the use of glyphosate and the benefits in terms of alfalfa forage quality were only temporary.

HERBICIDE AND INSECT RESISTANT TRAITS IN MICHIGAN CORN. Kathrin Schirmacher, James, J. Kells, and Christina D. DiFonzo, Graduate Student, Professor, Department of Crop and Soil Sciences, and Associate Professor, Department of Entomology, Michigan State University, East Lansing, MI 48824-1325.

Corn hybrids with stacked resistance traits are becoming more common in the marketplace. Two traits that are being stacked in corn hybrids are resistance to the western corn rootworm (*Diabrotica virgifera virgifera*) and glyphosate resistance. These hybrids offer new options for pest management but their adoption will only occur if there is an advantage over current practices. The objective of this three-year study was to examine the consistency of conventional and transgenic strategies for control of insects and weeds at four field sites with differing pest infestation levels.

Under low corn rootworm pressure, there was no added yield benefit from either the conventional control methods or the transgenic Bt hybrid. All control methods reduced damage to roots and protected corn yield under high corn rootworm pressure. Under high corn rootworm pressure, the transgenic Bt hybrid was the most effective at protecting yields and roots from damage. Natural corn rootworm pressures were difficult to predict from year to year.

Uncontrolled weeds decreased corn yields at all locations, even at low weed pressure sites. All weeds control strategies, either conventional or glyphosate-based provided yields similar to the weed free plots. Under high weed pressure, the glyphosate-based sequential herbicide application consistently provided the highest yields. Unlike corn rootworm, yearly weed pressures were easier to predict.

TOLERANCE OF SIX CLASSES OF DRY EDIBLE BEAN AND ADZUKI BEAN TO PRE AND POST APPLICATIONS OF HALOSULFURON. Gary E. Powell and Christy L. Sprague, Research Assistant and Assistant Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Six classes of dry bean and adzuki bean were planted in 2005 and 2006 at St. Charles, Michigan to determine the tolerance of dry bean and adzuki bean to halosulfuron applied preemergence (PRE) and postemergence (POST). Varieties of the different dry bean classes are as follows: ‘Vista’ navy bean, ‘Jaguar’ black bean, ‘Merlot’ small red bean, ‘Othello’ pinto bean, ‘Chinook 2000’ light red kidney bean, ‘Matterhorn’ great northern bean, and ‘Erimo’ adzuki bean. The plots were kept weed-free throughout the season. Visual injury, maturity ratings, and yield for PRE and POST applications of halosulfuron were compared with an untreated control using contrast statements. Injury from PRE applications of halosulfuron ranged from 6 to 19%, 30 d after planting (DAP) for all classes in 2005. Adzuki bean and the ‘Chinook 2000’ light red kidney bean exhibited the greatest injury. In 2006, only the adzuki bean was injured (9%). Injury consisted of stunting compared with the untreated control. Even though some stunting occurred with all classes in 2005 and only the adzuki bean in 2006, yields were only lower than the untreated control with ‘Jaguar’ black bean and ‘Chinook 2000’ light red kidney bean in 2005 (∀ = 0.1 level of significance). In both years, POST applications of halosulfuron caused stunting and chlorosis to all classes. Injury 4 to 6 d after treatment (DAT) ranged from 21 to 48% in 2005 and 12 to 56% in 2006. By 12 to 14 DAT, most dry bean classes started to out grow the injury; however injury in the adzuki bean increased. In 2005, injury was also greater for the light red kidney bean, 12 DAT. In 2005 yield was lower than the untreated control with adzuki bean (∀ = 0.05), light red kidney bean, and black bean (∀ = 0.1). However, in 2006 adzuki bean was the only bean were a significant reduction of yield was observed (>45% yield reduction). Differences in precipitation between 2005 and 2006 demonstrated the differences in recovery rates from POST halosulfuron injury to these different classes. Of all of the bean classes tested POST applications caused the greatest injury and yield reductions for adzuki bean, therefore POST applications of halosulfuron should be avoided to this class. Caution should also be taken when applying halosulfuron to black bean and light red kidney bean if conditions are not conducive for recovery from initial halosulfuron injury.

CORN INBRED RESPONSE TO BAS 799 AND OTHER GROWTH REGULATOR HERBICIDES APPLIED POSTEMERGENCE. Micheal D. K. Owen, James F. Lux*, Damian D. Franzenburg, Professor and Agricultural Specialists, Agronomy Department, Iowa State University, Ames, IA, 50011.

Herbicides with additives at 1x and 2x application rates were applied postemergence at the V4 growth stage to seven corn inbreds representing a range of herbicide sensitivities and mixture of early to late relative maturities. Herbicide treatments at 1x rates included: BAS 799, diflufenzopyr plus dicamba (Distinct), dicamba, and mesotrione plus atrazine at 5.0 oz (product/A), 0.125+0.05, 0.25, and 0.094+0.225 lb/A rates, respectively. Treatments, except mesotrione plus atrazine, included NIS and AMS at rates of 0.25 % v/v and 5.0 lb/100 gallon. COC and AMS were included with mesotrione plus atrazine at rates of 0.5% v/v and 5.0 lb/100 gallon.

Injury from BAS 799 at 1x and 2x was typically equal or less than the injury from 1x and 2x diflufenzopyr plus dicamba for all inbreds at 7 and 14 days after application (DAA). Injury at 28 DAA was mostly higher from 2x BAS 799 and 2x diflufenzopyr plus dicamba. Further, when comparing rate for rate, injury at 28 DAA was generally significantly less from BAS 799 compared to diflufenzopyr plus dicamba. Inbreds A, B, C, and D demonstrated the most injury, 5 to 33% at 28 DAA from 2x BAS 799 and 1x and 2x diflufenzopyr plus dicamba compared to inbreds E, F and G which demonstrated injury at 0 to 17%. Comparing inbreds A, B, C, and D, inbred D exhibited the least herbicide injury. Generally, injury to all inbreds from 1x dicamba was similar to 2x BAS 799 and 2x diflufenzopyr plus dicamba at 7 and 14 DAA. At 28 DAA, inbreds A, B, C, and D demonstrated less injury from 1x dicamba compared to 2x dicamba & diflufenzopy, but more injury than 2x BAS 799. Inbreds E, F, and G were the least affected inbreds when injury was evaluated 28 DAA. Dicamba 2x, compared to all other treatments resulted in the highest injury across the inbreds and ranged from 7 to 45% at 28 DAA. Mesotrione plus atrazine applied 1x resulted in 2 to 7% injury to inbreds D, E, F, and G when observed at 7 and 14 DAA, and no injury when evaluated at 28 DAA. Mesotrione plus atrazine 2x resulted in 3 to 15% injury to these same inbreds at 7 and 14 DAA, and 3 to 5% at 28 DAA. Inbreds A, B, and C demonstrated little to no injury from 1x and 2x mesotrione plus atrazine regardless of evaluation date.

Dicamba 2x resulted in significantly higher percentage of root fusion when averaged across inbreds at 55 DAA, compared to all other treatments. Inbreds B, C, E, and F exhibited 24, 50, 30, and 33% root fusion from dicamba 2x, respectively. Inbreds D and G exhibited 10 and 12 % root fusion from dicamba 2x, while inbred A was least affected at 1%. Root fusion averaged across inbreds was observed from 1x and 2x BAS 799 and diflufenzopyr plus dicamba, but none from mesotrione plus atrazine. No significant differences were found between these treatments, however, there were significant differences between the 2x rate of diflufenzopyr plus dicamba and the 1x and 2x rates of mesotrione plus atrazine. Of the inbreds exhibiting root fusion from 2x diflufenzopyr plus dicamba, inbred E was most affected at 14%. When averaged across inbreds, significant differences in height between treatments were observed at 59 DAA. The 2x rate of diflufenzopyr plus dicamba and 2x dicamba resulted in significantly shorter inbred heights overall compared to the other treatments. Differences in overall inbred heights were not significant when comparing 1x BAS 799, 1x diflufenzopyr plus dicamba, and the 1x and 2x rates of mesotrione plus atrazine.

ACCURACY OF WEEDSOFT FOR PREDICTING EARLY-SEASON COMPETITIVE LOADS FOLLOWING RESIDUAL HERBICIDES IN GLYPHOSATE-RESISTANT CORN. Daniel D. Schnitker, Bryan G. Young, William G. Johnson, and Mark M. Loux, Graduate Research Assistant and Associate Professor, Southern Illinois University, Carbondale, IL 62901, Associate Professor, Purdue University, West Lafayette, IN 47907, Professor, The Ohio State University, Columbus, OH 43210.

Full adoption of integrated weed management will never be realized until growers have the experience or tools necessary to estimate potential crop yield loss from weed competition. The utilization of weed management decision support software could have significant implications for weed management in glyphosate-resistant corn due to the reliance on postemergence glyphosate applications. Early and total season yield loss is calculated in WeedSOFT by using the competitive load parameter. Each weed species has a competitive index, which is multiplied by the number of plants/100 ft^2 and by a weed height multiplier to obtain the competitive load for that species. Field studies were conducted in Illinois, Indiana, and Ohio in 2006 using residual herbicides followed by a POST application of glyphosate. The objective of this research was to evaluate the competitive load of weeds present at the POST timing and test the accuracy of WeedSOFT at predicting crop yield loss.

Linear regression analysis by individual state and pooled across states was conducted to determine the correlation between predicted and observed yields. A slope equal to one indicates a close relationship between predicted and observed yields. The slope value estimate for Illinois was equal to one. However, WeedSOFT underestimated yield losses in Indiana, Ohio, and combined across states, especially when yield loss estimations were minimal. Further analysis is justified to determine what underlying factors contribute to the inaccuracy of WeedSOFT prediction models under certain environments and weed dynamics.

VARIOUS ASPECTS OF GLYPHOSATE RESISTANT ALFALFA MANAGEMENT. Benjamin L. Fochs*, Gregory K. Dahl, Joe V. Gednalske, Eric P. Spandl, Robert Schoper, and Dennis Gehler, Research Agronomist, Research Coordinator, Product Development Manager, Agronomist and Agronomist, Agriliance LLC, St. Paul, MN, and Forage Product Manager, CROPLAN GENETICS, St. Paul, MN.

The development of glyphosate-resistant alfalfa offers effective weed control, enhanced stand establishment, flexibility, and ease to forage producers. Several studies were conducted to understand aspects of this new management system including the effect of glyphosate applications on weed control, crop tolerance, and successful termination of the stand.

Field research trials were conducted at the University of Wisconsin-River Falls, Mann Valley Farm to evaluate weed control at establishment and crop tolerance. Glyphosate rates of 0.86 and 2.60 kg ae/ha were applied when alfalfa was 20 to 24 cm in height at establishment and after harvest to new growth at 12 to 15 cm in height. . All treatments provided 95% or greater weed control with no visible injury to the alfalfa stand.

A trial was conducted to evaluate the effectiveness of various herbicides in terminating the glyphosate-resistant alfalfa. Tankmix applications of glyphosate and dicamba at 0.86 kg ae/ha and 0.56 kg ai/ha and glyphosate, dicamba, and 2-4D ester at 0.86 kg ae/ha, 0.28 kg ai/ha and 1.12 kg ai/ha respectively were applied to established alfalfa at 30 to 35 cm in height. Herbicides provided moderate control of alfalfa, dandelion and Kentucky bluegrass at 6 days after treatment. Plots were moldboard plowed 17 days after treatment to achieve complete control.

Glyphosate-resistant alfalfa offers a new effective choice in weed control with additional management necessary when terminating stands

HIGH CLEARANCE SPRAYER FOR WEED CONTROL PLOTS. Jeffrey G. Tank*, Gregory K. Dahl, Joe V. Gednalske and Eric P. Spandl, Research Agronomist, Research Coordinator, Product Development Manager and Agronomist, Agriliance LLC, St. Paul, MN 55164.

A high clearance sprayer was manufactured to conduct pesticide and adjuvant research on tall crops. This tractor mounted sprayer was developed to spray plots with tasseled corn, make broadcast preemergent and postemergent applications on various crops, and spray deposition trials using various adjuvants. The sprayer needed to be versatile and easy to clean out between applications.

A frame from a pull type sprayer provided the starting point. Steel tubing was used to reinforce and modify the sprayer. A twenty-five foot boom was built to allow four rows of corn planted thirty inches apart to be sprayed on either side of the tractor. The sprayer was constructed to allow quick attachment to the tractor, easy vertical adjustment in two inch increments, and a folding boom for easy transport.

Connections where made with couplers and valves for fast and easy cleanout when switching treatments. An in-cab controller allowed the operator to monitor and adjust spray pressure and activate any combination of the three boom sections. A Filter, solenoids and valves were mounted on the side for easy access and the pump was placed below the tank for improved cleanout.

The cost of the sprayer was much less than an investment in a self propelled high clearance sprayer.

SENSITIVITY OF TEFF (*ERAGROSTIS TEF*) TO VARIOUS HERBICIDES. Scott Feldt, Christopher L. Schuster, Brian L. S. Olson, and J. Anita Dille, Undergraduate Student, Graduate Student, Assistant Professor, Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66502.

Teff is an indigenous cereal crop of Ethiopia and is gaining interest in the U.S. as a gluten-free replacement for wheat. Field studies were conducted near Manhattan and Colby, KS in 2006 to evaluate the response of teff to various preemergence (PRE) and postemergence (POST) herbicides. PRE applications of atrazine (1.1 or 2.2 kg ha^{-1}) or *S*-metolachlor (2.13 kg ha^{-1}) were applied at sowing and POST applications of 2,4-D (3.59 kg ha^{-1}), dicamba (3.59 kg ha^{-1}), bromoxynil (0.42 kg ha^{-1}), carfentrazone (0.03 kg ha^{-1}), halosulfuron (0.04 kg ha^{-1}), prosulfuron (0.03 kg ha^{-1}), mesotrione (0.11 kg ha^{-1}), sethoxydim (0.32 kg ha^{-1}), and glyphosate (0.84 kg ha^{-1}) were applied when teff was 10-cm tall. Teff injury was visually evaluated one and eight weeks after treatment (WAT) on a scale of 0 (no injury) to 100 (mortality). Teff was harvested at maturity to determine yield. Data were combined over locations due to a lack of interactions. Atrazine and *S*-metolachlor applied PRE resulted in greater than 90% injury of teff at 8 WAT. POST applications of 2,4-D, dicamba, bromoxynil, carfentrazone, halosulfuron, and prosulfuron resulted in less than 5% injury of teff at 8 WAT. Mesotrione, sethoxydim, and glyphosate resulted in yield reductions of 30, 50, and 99%, respectively, as compared to the weed-free check. Substantial seed loss during harvest indicated that teff production could possibly lead to teff becoming an annual weedy grass in corn and grain sorghum fields. Therefore, a follow-up study was performed in the greenhouse at Manhattan to determine the early season competitiveness of teff with corn and grain sorghum. Soil was recovered from the upper 2 cm portion of 0.06 m^2 areas in the field following harvest, spread in a polypropylene tray containing a 1:1 (v/v) mixture of sand:Morril loam soil, and placed in the greenhouse. Corn or grain sorghum seed were planted in the trays and treated PRE with atrazine (1.1 or 2.2 kg ha^{-1}), mesotrione (0.22 kg ha^{-1}), or *S*-metolachlor (2.13 kg ha^{-1}). Trays left untreated indicated that approximately 90 seeds of teff per 0.06 m^2 were lost during harvest. Corn and grain sorghum biomass was reduced by 10 and 13%, respectively, by 3 weeks after emergence (WAE) when trays were untreated. Atrazine, mesotrione, or *S*-metolachlor provided greater than 98% control of teff at 3 WAE and resulted in no reductions in corn or grain sorghum biomass. Results indicate that numerous POST herbicidal compounds are safe for use on teff with minimal crop injury at 8 WAT. Substantial harvest loss of teff seed will require corn or grain sorghum fields to be treated with a PRE herbicide to control emerging teff plants.

CONTROL OF DOWNY BROME IN WINTER WHEAT WITH PROPOXYCARBAZONE AND MESOSULFURON. Steven R. King* and Kevin B. Thorsness, Assistant Professor, Montana State University-Southern Agricultural Research Center, Huntley, MT 59037 and Bayer CropScience, Fargo, ND, 58103.

In Montana, downy brome (*Bromus tectorum*) is becoming one of the most troublesome and difficult to control weeds in winter wheat (*Triticum aestivum*). Increased no-tillage production practices, warmer winters, and limited herbicide choices have facilitated the increase in downy brome populations. In 2005-06, an experiment was performed to evaluate the efficacy of propoxycarbazone and mesosulfuron applied alone or in combination for the control of downy brome in winter wheat. Four postemergence treatments of propoxycarbazone were applied in the fall of 2005. Sequential treatments applied in the spring of 2006 consisted of no herbicide, propoxycarbazone alone, propoxycarbazone plus mesosulfuron, and mesosulfuron alone. These treatments were compared to sulfosulfuron applied in the fall or in the spring. The experiment also contained a nontreated control. The experiment was designed as a randomized complete block and contained four replications. Winter wheat injury and downy brome control were rated throughout the growing season and wheat yield was determined at harvest. All treatments applied in the fall did not injure wheat at any rating time. Sequential spring applications of propoxycarbazone alone, propoxycarbazone plus mesosulfuron, and mesosulfuron alone caused wheat injury of 9, 14, and 5%, respectively, 8 days after the spring treatment. However, by harvest no injury was apparent from any treatment. Downy brome control prior to the application of sequential treatments ranged from 56 to 68% and there was no difference among treatments. In June, propoxycarbazone applied alone in the fall controlled downy brome equivalent to either sulfosulfuron treatment. Fall applied propoxycarbazone followed by spring applications of propoxycarbazone alone, propoxycarbazone plus mesosulfuron, or mesosulfuron alone controlled downy brome 87, 92, and 90%, respectively, in June. Sequential treatments controlled downy brome greater than propoxycarbazone or sulfosulfuron applied in the fall or the spring application of sulfosulfuron. No difference in winter wheat yield was observed among treatments regardless of the level of downy brome control. Results indicate that spring applications of propoxycarbazone, propoxycarbazone plus mesosulfuron, or mesosulfuron alone following a fall application of propoxycarbazone are efficacious for the control of downy brome.

DOSE RESPONSE CURVES FOR KIH-485 IRRIGATED CORN WITH HERBICIDES. Stevan Z. Knezevic, Jon E. Scott* and Peter Porpiglia, Haskell Ag. Lab., University of Nebraska, Concord, NE, 68728-2828, and Kumia America, White plains, New York.

KIH-485 is a new herbicide under development. Four field studies were conducted in 2006 at Brunswick and Concord to describe and compare dose response curves for KIH-485 at four soil types (eg. 1%OM, 2%, 3%, and 4% OM) for control of green foxtail, field sandbur, large crabgrass, velvetleaf and tall waterhemp. Dose response curves were fit, and ED90 values (effective dose that provides 90% weed control) were determined utilizing the **R** and *drc* software package. Generally, an increase in OM resulted in higher ED90 values for all weed species. For example, the ED90 (90% control) for green foxtail was 115 g ai/ha for soils with 1% OM, while 300 g ai/ha was calculated for soils with 3% OM. Similar response was observed for other weed species. The proposed label rate for KIH might be between 200-250 g ai /ha, which would provide excellent control of most weed species for at least first four weeks of the growing season on soils up to 3% OM. For example, at 28 DAT field sandbur was controlled with 228 g ai/ha on soils with 1% OM, green foxtail with 115g and 121g ai/ha on soils with 1% and 2% OM, as well as velvetleaf and tall waterhemp on soils with 3% OM with 189 g ai/ha and 240 g ai/ha. Most soils in Nebraska contain no more than 3% OM, thus the KIH has a good potential for PRE use in corn as it provided excellent early season control of our major
weed species (sknezevic2@unl.edu).

UTILIZING **R** SOFTWARE PACKAGE FOR DOSE RESPONSE STUDIES: THE CONCEPT AND DATA ANALYSIS. Stevan Z. Knezevic, Jens C. Streibig, and Christian Ritz, Haskell Ag. Lab., University of Nebraska, Concord, NE, 68728-2828 and Royal Veterinary and Agricultural University (KVL), Copenhagen, Denmark **.**

Advances in statistical software allow both standard and more complex statistical methods for non-linear regression analysis of dose response curves to be carried out conveniently by non-statisticians. One such statistical software is the freely available program **R** with the *drc* extension package. The *drc* package can: (1) simultaneously fit multiple dose-response curves, (2) compare curve parameters for significant differences, (3) calculate any point along the curve as the response level of interest, commonly known as an effective dose (eg. ED30, ED50, ED90), and determine its significance, (4) generate graphs for publications or presentations. We believe that when it comes to dose response data, the *drc* package has advantages over many currently available statistical software programs for non-linear regression analysis. Therefore, our objectives are to: (1) provide a review of few common issues in dose response curve fitting, (2) facilitate the use of up-to-date statistical techniques for analysis of dose response curves and (3) invite further debate on the subject (sknezevic2@unl.edu).

ISOXAFLUTOLE DISSIPATION UNDER FIELD CONDITIONS IN WEST CENTRAL MINNESOTA. Sharon K. Papiernik, William C. Koskinen, Brian Barber, and Gary Amundson, USDA-Agricultural Research Service, Morris, MN 56267 and St. Paul, MN 55108.

Isoxaflutole is a relatively new pre-emergence herbicide used in corn production. Isoxaflutole's phytotoxic metabolite (DKN) has a low sorption coefficient and may be persistent in soil, indicating that this herbicide may have a tendency to contaminate water resources through leaching and runoff. Two-year field dissipation studies were conducted in three soil types (sandy loam, loam, and clay loam) in west central Minnesota to determine the rate at which isoxaflutole+DKN dissipates under relatively cool, wet soil conditions. Separate plots were treated with isoxaflutole and potassium bromide, a non-sorbed, non-degraded tracer. Soil cores were collected six times during the growing season to a depth of 1 m and sectioned into 0-10, 10-20, 20-40, 40-60, and 60-100 cm increments. Bromide or herbicide concentration was measured in replicate samples at each depth at each sampling time. Isoxaflutole+DKN dissipated by both degradation and transport in each soil, with a dissipation half-live (DT50) of 7-17 d. Leaching of low concentrations of herbicide (<0.03 μg g-1) below 40 cm was observed in both years, but leaching was not a major dissipation mechanism. Because Br^{-} concentrations decreased by <20% in the first 10 days in each soil, much of the herbicide dissipation is attributed to transformation. These results will provide information for the development of best management practices for this herbicide.

EVALUATION OF PREPLANT APPLICATION INTERVALS FOR A CHLORIMURON-ETHYL PLUS TRIBENURON-METHYL PREMIX IN SOYBEANS. Helen A. Flanigan, Marsha J. Martin, and Gregory R. Armel, Field Development Representatives and Product Development Specialist, DuPont Ag and Nutrition, Wilmington, DE 19880.

Canopy® EX is a soybean herbicide premix containing tribenuron-methyl and chlorimuron-ethyl in a 1:3.3 ratio. When applied in the fall or as an early spring preplant application, Canopy® EX provides burndown and residual control of several key broadleaf weeds. Currently, tribenuron-methyl cannot be applied to soybeans unless applications are made at least 45 days before planting, thereby limiting application flexibility. Therefore, research was initiated to evaluate soybean crop response from a variety of tribenuron-methyl applications in order to determine the shortest possible re-crop interval which will afford optimal soybean safety.

Studies were conducted in 2004 at 10 contract and university locations to evaluate soybean response at 0, 3, 7, 14, and 30 days after applications of tribenuron-methyl at 9, 18, and 36 g ai/ha. In order to maximize potential crop response, plots were irrigated with 2.54 cm of water immediately following soybean planting. Soybeans planted on the day of tribenuron-methyl application displayed between 12 and 20% response. Tribenuron-methyl at 36 g ai/ha caused 7 and 17% response to soybeans planted at 3 and 7 days after application, respectively. Regardless of location, soybeans displayed little to no response (0-1%) when planted between 3 and 30 days after applications of tribenuron-methyl at 9 and 18 g ai/ha.

Additional studies were also conducted with university cooperators in 2006 to evaluate Canopy® EX at 23, 34, and 45 g ai/ha applied 7 or 14 days before soybean planting. Soybeans planted 7 days after a Canopy® EX application had minimal response across all rates with only one trial reporting more than 2% crop response by 28 days after planting. No crop response was noted from trials planted 14 days after application.

WEED CONTROL PERFORMANCE OF KIH-485 PLUS ATRAZINE IN CORN. Hisashi Honda, Masanori Kobayashi, Junichi Watanabe, Yoshihiro Yamaji, and Ryo Hanai, Kumiai Chemical Industry Co., Ltd., Tokyo, Japan. Peter J. Porpiglia and Osamu Watanabe, Kumiai America, White Plains, NY.

KIH-485 is being developed primarily as a pre-emergence herbicide but with flexible application timings in corn and other crops. While KIH-485 provides good efficacy on grasses and broadleaf weeds; KIH-485 alone does not always provide complete efficacy against velvetleaf (*Abutilon theophrasti*), ragweed (*Ambrosia* spp.) and smartweed (*Polygonum* spp.) or other broadleaf weeds. Compatibility of KIH-485 (WG, SC) with atrazine (WG, L) was generally complimentary and has exhibited synergistic efficacy on velvetleaf in greenhouse trials. In field trials, pre-mixed formulations of KIH-485 + atrazine (WG) have exhibited good efficacy as a total pre-emergence herbicide. This combination should provide complete control of many typical corn-belt weed species. For example, it is appears that 209 g/ha of KIH-485 plus 1336 g/ha of atrazine has good, broad-spectrum efficacy as a standard premix product and specifically better efficacy on velvetleaf and Pennsylvania smartweed (*Polygonum pensylvanicum*) than either product alone. Based on our results, KIH-485 plus atrazine has the potential to become another viable option for corn production.

EFFECT OF TIMING OF TOPDRESSING NITROGEN FERTILIZER RELATIVE TO POSTEMERGENCE APPLICATIONS OF AE F130060 ON WHEAT INJURY. James R. Martin, Charles R. Tutt, and Dorothy L. Call, Extension Professor, Research Specialist, and Technician, Department of Plant and Soil Sciences, University of Kentucky, Princeton, KY 42445.

AE F130060 (proposed common name mesosulfuron methyl) is a relatively new foliar - applied herbicide used to manage weedy gasses after wheat emergence. It is an Acetolactate Synthase (ALS) inhibitor that can injure wheat; consequently, it is formulated with the safener, mefenpyr diethyl. There have been isolated cases in Kentucky where AE F130060 injured wheat, particularly when it was applied near the time of topdressing nitrogen fertilizer. The herbicide label for AE F130060 cautions against making applications within 14 days of topdressing ammonium nitrogen fertilizer due to the risk of crop injury.

The objective of this research was to evaluate crop injury and possible effects on wheat yield relative to using AE F130060 near the same time as nitrogen fertilizer applications.

'Pioneer 25R35' wheat was planted October 12, 2005 using no-tillage practices. A premix of thifensulfuron plus tribenuron was applied January 12, 2006 to keep plots as weed free as possible. In order to help eliminate variability from other pests, lambda cyhalothrin insecticide was applied in the fall and spring and propiconazole fungicide was applied in the spring.

The commercial formulation of AE F130060 with the safener was applied at a rate of 0.21 oz ai/A with a CO_2 back-pack sprayer on March 10, 2006. A non-ionic surfactant at 0.5% v/v plus 28% liquid nitrogen at 1 qt/A were included in the spray mixture as additives for AE F130060. Stream bars were used to apply 28% liquid nitrogen fertilizer at 120 lbs of actual nitrogen /A approximately 2 hours before AE F130060. This treatment was compared with applying liquid nitrogen fertilizer as a split treatment at 40 and 80 lbs/A of nitrogen at approximately 3 weeks before and 3 weeks after AE F130060, respectively. Ammonium nitrate and urea were dry forms of nitrogen fertilizer that were hand applied as a single treatment at 120 lbs of nitrogen/A on the same day as AE F130060, but were not included are split treatments. Each nitrogen treatment that was associated with AE F130060, had the same nitrogen fertilizer treatment but without AE F130060.

Wheat injury in the form of yellow or necrotic leaves and stunted plants tended to be greatest where AE F130060 and 28% liquid nitrogen were applied the same day. Based on Normalized Difference Vegetative Index (NDVI) readings, some discoloration was observed in all treatments where AE F130060 was applied, however the difference in NDVI readings dissipated by five weeks after AE F130060 was applied. Wheat plants that received both AE F130060 and 28% liquid nitrogen fertilizer the same day were 2.6 inches shorter at one week after treatment than those that were not treated with AE F130060 but received liquid nitrogen. This stunting was still obvious by four weeks after treatment but diminished by the time plants matured.

Wheat streak mosaic virus was observed in this study and significantly impacted grain yield in a portion of the field. The plots that were not substantially affected by the virus were used for statistical comparisons for yield. AE F130060 limited yield in nearly every case except where ammonium nitrate was used. The greatest difference occurred where AE F130060 and 28% liquid nitrogen were applied the same day. Applying liquid nitrogen as a split treatment of three weeks before and three weeks after AE F130060 also reduced wheat yield relative to applying liquid nitrogen as a split treatment without AE F130060.

In summary, topdressing nitrogen fertilizer on the same day as spraying AE F130060 has potential to injure wheat and limit grain yield, particularly with 28% liquid nitrogen. Applying 28% liquid nitrogen as split applications seemed to limit injury from AE F130060, yet yields were still low where the herbicide was used compared to where it was not applied.

EFFECT OF GLYPHOSATE RESISTANT ALFALFA SEEDING DENSITY ON FORAGE PRODUCTION AND COMPOSITION. David E. Hillger, Richard H. Leep and James J. Kells, Research Associate and Professors, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824-1325

Current recommendations for alfalfa seeding rates are based on conventional varieties. The introduction of glyphosate resistant alfalfa offers a new management system for establishing alfalfa. Determining optimum seeding rates will provide forage producers with the information to maximize yield, quality, and profitability with this new technology. Multi-year field experiments were conducted to determine the effect of weed control on forage production, forage quality and alfalfa stand establishment at varying seeding rates in glyphosate resistant alfalfa. Seeding rates of 4.5, 9.0, and 17.9 kg ha^{-1} were evaluated. Weed control methods in the establishment year included: no herbicide, glyphosate applied once before the first harvest, and glyphosate applied before the first harvest and 7 to 10 days following each harvest. Herbicide treatments were not applied after the establishment year. The establishment year results showed no crop injury from glyphosate treatments. In the 2005 establishment year, the greatest differences in alfalfa, weed and total forage yields were observed at the first and second harvests. There were no differences in alfalfa, weed and total forage yields across seeding rates or herbicide treatments at the third and fourth harvests. However in 2006, differences in the alfalfa, weed and total forage were observed due to the seeding rates, the herbicide treatment or both at each harvest. Alfalfa yield increased and weed yield decreased with increased seeding rates. The application of glyphosate significantly increased the alfalfa and total forage yield for the second and third harvest in the 2006 establishment year. The results for the second season of the 2005 establishment study showed no differences in the alfalfa, weed and total forage yields at all harvests. In the 2005 establishment study, the reduction in the number of alfalfa crowns in the fall compared to the spring was significantly greater at the 17.9 kg ha^{-1} seeding rate than at the lower seeding rates. In 2006, this trend continued but there were no significant differences based on seeding rate.

BENEFITS OF RESIDUAL HERBICIDES FOR WEED CONTROL IN GLYPHOSATE-RESISTANT NO-TILL SOYBEAN. Jon-Joseph Q. Armstrong and Christy L. Sprague, Graduate Research Assistant and Assistant Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Field trials were established at three sites in Michigan in 2006 to evaluate the effect of adding a herbicide with residual activity during early preplant (EPP) burndown application to reduce early-season weed competition in no-till drilled soybean. Additionally, the effect of glyphosate application at various postemergence (POST) timings was also evaluated to determine the optimal timing following an EPP treatment. EPP treatments were scheduled to be applied 7 days before planting. Treatments consisted of glyphosate plus 2,4-D ester alone and in combination with chlorimuron plus metribuzin, s-metolachlor plus metribuzin, pendimethalin, flumioxazin, linuron, or imazethapyr. Glyphosate was applied POST at 0.84 kg ae/ha when weeds in the glyphosate plus 2,4-D ester EPP treatment were 10, 20, or 40 cm in height. Visual ratings of weed control were taken prior to each POST application to evaluate the efficacy of EPP treatments. Season-long control of common lambsquarters, present at two of three sites, and common ragweed, present at all sites, ranged from 5% to 99% for all EPP residual treatments. Though weed control varied among the EPP treatments, control of all species was at least 90% after the respective POST glyphosate application. Across all locations, yields of EPP residual herbicides followed by glyphosate POST were not significantly different compared with the glyphosate plus 2,4-D EPP treatment followed by glyphosate POST; however, there was a trend of higher yields for the EPP residual herbicide treatments followed by glyphosate at the 20 cm application timing. Yields were similar for chlorimuron plus metribuzin, s-metolachlor plus metribuzin, and flumioxazin EPP treatments alone compared with the same EPP treatments followed by glyphosate POST, indicating that these herbicides provided sufficient weed control until crop canopy closure.

PLANTS POISONOUS OR HARMFUL TO HORSES EDUCATIONAL POSTER. Krishona Martinson, Mike Murphy, and Lynn Hovda, Assistant Extension Professor and Professor, University of Minnesota, St. Paul, MN 55108 and Minnesota Racing Commission Veterinarian, Canterbury Park, Shakopee, MN 55379.

The horse industry has grown rapidly in Minnesota in the last five years, and is now estimated to be a $1 billion industry. The 2002 USDA Census of Agriculture indicated there were 14,289 horse and pony farms in Minnesota; an 80 percent increase from the 1997 census. The University of Minnesota conducted a state-wide survey of 1,000 Minnesota horse owners during the spring of 2004, and poisonous plants were one of the top ten topics of interest to MN horse owners. Recent hoary alyssum outbreaks in purchased hay, and concerns over the use of black walnut shavings at Canterbury Park have also raised concerns with MN race horse owners, and owners of MN Thoroughbred farms have raised concerns about the toxicity of Maple, Oak, or Cherry trees around broodmares, foals or yearlings. Both the U of M Extension Service and College of Veterinary Medicine receive numerous requests annually for information regarding the effect of poisonous plants on horses. Because no comprehensive information source on plants poisonous or harmful to Midwest horses existed, the MN Racing Commission funded the development of a poster. The objective of the poster is to educate horse owners on poisonous and harmful plants that effect horses in the Upper Midwest and to provide clear, color photos to aid in plant identification. Plants identified on the poster include: black walnut, brakenfern, buttercup, clover, chokecherry, common cocklebur, corn cockle, fescue, foxglove, foxtail, hoary alyssum, field horsetail, maple, mustard, oak, poison hemlock, sweetclover, waterhemlock, white snakeroot, and yew.

INFORMATION DISCOVERY FROM CANADA THISTLE CONTROL RESEARCH DATA BY USING CLASSIFICATION MINING. Jingkai Zhou, Janet Davidson-Harrington, and Calvin G. Messersmith, PostDoc, Research Specialist, and Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105

Data-mining is a technique that extracts hidden predictive information that experts may miss because it lies outside their expectation. Classification mining, which is a data-mining task, aims to identify characteristics that indicate the group to which each case belongs. The classifier (model) from classification mining can be used both to understand existing data and to predict future trends and behaviors, which allows users to make proactive, knowledge-driven decisions. A classification mining function has been developed based on Canada thistle control research data, but this function with limited modification can mine other databases. One goal of classification mining functions is to calculate the entropy (data stability) for each predictive attribute, such as temperature before or after treatment. The predictive factor(s) with the lowest entropy is the factor(s) that has the most effect on the predicted factor, such as control. For example, using 2,4-D for Canada thistle control the entropy of minimum and maximum temperature at 1 d after 2,4-D treatment is 0.901 and 0.857, respectively, indicating that maximum temperature after treatment has more effect than minimum temperature on Canada thistle control by 2,4-D. Another goal is create a classifier. First, a classifier, i.e., a decision tree, is built that describes a predetermined set of data classes or concepts. When the accuracy of the classifier is considered acceptable, the classifier can be used to classify future data.

DEVELOPMENT AND UTILIZATION OF AN INTEGRATED PEST MANAGEMENT ASSESSMENT TOOL. Ryan P. Miller, Lisa M. Behnken, and Fritz R. Breitenbach, Assistant Extension Professor, University of Minnesota, Albert Lea Regional Center, Albert Lea, MN 56007-4001, Extension Professor, University of Minnesota, Rochester Regional Center, Rochester, MN 55904-4915, Associate Extension Professor, University of Minnesota, Rochester Regional Center, Rochester, MN 55904-4915.

The University of Minnesota Integrated Pest Management (IPM) Assessment for Field Crops in Southern Minnesota was adapted from the University of Wisconsin Pest Management Assessment for Field Corn (12-6-01). The Minnesota IPM assessment was started in 2003 and has been revised yearly through 2006 to provide the most accurate and relevant IPM Assessment. The Minnesota IPM Assessment covers all major agronomic crops in Southern MN and includes questions on general agronomics, weed management, insect management and disease management. The IPM assessment was conducted in 2003, 2004, 2005, and 2006 at Private Pesticide Applicator Training (PPAT) meetings in Southern Minnesota. A total of 1727 assessments have been completed with 150, 415, 440, and 722 private applicators completing the assessment in 2003, 2004, 2005, and 2006 respectively. The farmers attending the PPAT meetings completed the self assessment at the beginning of the session and various IPM topics were covered during the remainder of the meeting. Results from the assessments were compiled and analyzed to expose opportunities for increased IPM adoption, and to help educators develop programs that would assist farmers in implementing more IPM practices. When participants were asked about their weed control philosophy 15 to 20 percent of growers were resolved to complete weed control, while 40 to 50 percent of growers wanted to achieve a high level of weed control while tolerating some weed escapes, and only 25 to 45 percent believed in weed control with the greatest net return. Another example is that only 70 percent of growers scout all of their fields for weeds, and only 50 percent of growers scout their fields 7-14 days after a postemergence herbicide application. From the 2006 assessment 77 percent of growers are planting Roundup Ready or Roundup Ready/Liberty Link stacked corn hybrids, and 86 percent of growers planted Round Ready or Roundup Ready/STS stacked soybean varieties. Also in the 2006 survey growers listed their most problematic broadleaf weeds as common lambsquarters (43%), giant ragweed (36%), waterhemp species (35%), velvetleaf (29%), common ragweed (21%), and pigweed species (12%). IPM assessment summaries demonstrated opportunities for additional educational programming due to the incomplete adoption of IPM tactics.

SOYBEAN HERBICIDE PROGRAMS FOR EFFECTIVE MANAGEMENT OF GIANT RAGWEED. Anthony F. Dobbels and Mark M. Loux, Research Associate and Professor, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210.

Giant ragweed has been ranked as one of the worst weeds in corn and soybean production, and continues to be problematic for many producers in Ohio. A single application of glyphosate or other POST herbicides often fails to adequately control giant ragweed, due to its rapid growth and ability to emerge after POST herbicides are applied. A field study was conducted to determine the effectiveness of herbicide programs consisting of PRE followed by POST herbicides, or multiple POST herbicide applications, for giant ragweed control in glyphosate-resistant soybean. A secondary objective was to determine the effect of PRE herbicides on giant ragweed population density and size at the time of POST herbicide application.

The PRE herbicide treatments, imazaquin (0.14 kg/ha), cloransulam (0.024 kg/ha) plus flumioxazin (0.071 kg/ha), and chlorimuron (0.073 kg/ha) plus metribuzin (0.21 kg/ha) controlled 70 to 77%, 65 to 82%, and 20 to 55% of the giant ragweed, respectively, at the time of the POST herbicide application. Control was due primarily to a reduction in giant ragweed size, not a reduction in population density. Giant ragweed population densities at the time of POST application ranged from 54 to 280 plants per plot (18 m^2), and were not affected by PRE herbicide treatment. Application of PRE herbicide resulted in a greater proportion of giant ragweed plants less than 7 cm tall, compared to treatments without PRE herbicides. Since POST herbicides were applied based on giant ragweed height, the use of PRE herbicides allowed POST herbicides to be applied 7 days later, compared to treatments consisting of only POST herbicides.

The most effective treatments, which provided greater than 95% control of giant ragweed at the time of soybean harvest, included: sequential POST applications of glyphosate (0.86 kg a.e./ha) or fomesafen (0.17 kg/ha); and PRE application of imazaquin followed by POST glyphosate. These treatments resulted in a complete absence of seed-producing giant ragweed plants. Control for most other combinations of PRE herbicides with POST glyphosate or fomesafen ranged from 80 to 93%, which was similar to control with a single POST application of glyphosate. These treatments resulted in 2 to 6 seed-producing giant ragweed plants per plot at the end of the season. The addition of a diphenyl-ether herbicide to POST glyphosate treatments did not improve giant ragweed control or further reduce the number of plants producing seed, compared to glyphosate alone.

FACTORS AFFECTING GLYPHOSATE CONTROL OF COMMON LAMBSQUARTERS. Chris M. Boerboom[1], David E. Stoltenberg[1], Mark R. Jeschke[2], Timothy L. Trower[3], and John M. Gaska[3], [1]Professor, [2]Graduate Student, and [3]Outreach Specialist, University of Wisconsin, Madison, WI 53706.

Common lambsquarters is the most problematic weed in soybean and one of the top three most problematic weeds in corn in Wisconsin. Glyphosate is the most frequently used herbicide for weed control in soybean and its use is increasing in corn. Several factors may account for inconsistent common lambsquarters with glyphosate. Of these factors, we investigated the potential for growth stage, environmental conditions, rain, and dust to contribute to poor common lambsquarters control.

Dose response experiments were conducted to determine if common lambsquarters growth stage affects sensitivity to glyphosate. Glyphosate at rates up to 3 kg ae ha^{-1} was applied to 8- to 10-cm and 18- to 20-cm tall common lambsquarters. Four replicated field experiments were conducted at three sites over 2 years. The dose that reduced biomass by 50% (ED_{50}) was determined and the ED_{50} values of the two growth stages were compared. At three sites, the ED_{50} values were 1.9 to 8.9 times greater when glyphosate was applied later to the taller common lambsquarters than when applied earlier to smaller common lambsquarters. The ED_{50} values were similar at the fourth site. The reduced efficacy of glyphosate applied to taller common lambsquarters may be partially responsible for its inconsistent control. Agri-professionals in Wisconsin reported in 2006 that over 25% of applications in soybean are made to common lambsquarters greater than 20-cm tall.

A replicated field experiment was conducted in 2006 to determine if weather conditions affect common lambsquarters control when glyphosate is applied under identical application parameters. Glyphosate at 0.84 kg ha^{-1} plus 1 kg ha^{-1} ammonium sulfate was applied to 9-cm tall common lambsquarters during 15 dates from June 14 to July 31 and to 33-cm tall common lambsquarters during 3 dates from August 3 to 7. Plots were tilled sequentially to produce plants of the desired size. Glyphosate was applied on 18 dates, which ranged widely in environmental conditions. Daily temperatures were as low as 10 C and as high as 33 C on the day of application. Despite these variations, common lambsquarters control was 98 to 100% at 14 days after treatment on 17 of the 18 application dates. On the remaining date, common lambsquarters was not controlled because 1 mm of rain fell as the application was being completed. These results suggest common lambsquarters can be consistently controlled over a range of environmental conditions when small plants are treated.

Replicated field experiments were conducted to determine the effect of rain on common lambsquarters control by glyphosate. Glyphosate at 0.84 kg ha^{-1} was applied to common lambsquarters at 0.5, 1, 2, and 4 hr prior to a simulated rainfall. Rainfall was simulated by applying high volumes of water with a field sprayer. Two glyphosate formulations were tested with and without the addition of 0.25% nonionic surfactant. Common lambsquarters was up to 30-cm tall in 2005 and up to 25-cm tall in 2006. Common lambsquarters control by glyphosate was reduced by simulated rain after 4 hr in both years. Without rainfall, glyphosate formulation or the addition of surfactant did not affect the level of common lambsquarters control in 2005 and control exceeded 90%. In 2005, additional surfactant increased control with both glyphosate formulations with or without rainfall and control exceeded 95% without rainfall.

Two demonstrations were conducted to determine if the application of dust affects common lambsquarters control by glyphosate. At two field locations in Wisconsin, dust, which was generated with a lawn mower or leaf blower, was spread over common lambsquarters. In paired plots, the dust was removed from one plot by spraying a high volume of water on the plot. After the leaves dried, the plots were sprayed with 0.84 kg ha^{-1} of glyphosate. At both locations, the application of dust visually reduced common lambsquarters control and the plants appeared to be nontreated at one site.

Numerous factors affect the ability of glyphosate to control common lambsquarters. Growth stage, glyphosate rate, rain, and dust affected control in these experiments and demonstrations. Other factors such as time of day, carrier volume, and potentially resistant biotypes may also affect control. Glyphosate applications at early common lambsquarters growth stages should increase the consistency of performance, but may not overcome some of these factors.

ON-FARM TRIALS FOR SUSTAINABLE WEED MANAGEMENT IN THE NORTH CENTRAL REGION. Hill, E. C. and K. A. Renner, Research Associate and Professor, Michigan State University, Department of Crop and Soil Sciences, East Lansing, MI 48824-1325.

Seven on-farm trials were conducted throughout the North Central region as a part of a NCR-SARE grant, which first fostered the creation of the Michigan State University Extension (MSUE) bulletin "Integrated Weed Management 'One Year's Seeding…'" (E-2931). The on-farm trials were all conducted on certified organic farms and designed by the growers to test some of the alternative weed management strategies discussed in the bulletin. Areas of study included flaming, using cover crops, planting at alternative dates, and varying cultivation equipment. A second year of data will be collected next summer from many of the trials. The results of these studies will contribute to a better understanding of alternative weed management, and information collected from these trials will be included in a new supplemental bulletin to the "Integrated Weed Management" guide. The topics included in the supplemental bulletin are based on interest expressed by growers in a survey of the IWM bulletin.

CUT-STUMP TREATMENT OF SALTCEDAR ON THE CIMARRON NATIONAL GRASSLAND.

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 western United States. In Kansas, saltcedar infests more than 20,000 ha and is particularly a problem along the Cimarron and Arkansas watersheds. Initial research conducted in 2004 indicated that cut-stump treatments containing triclopyr or imazapyr provided greater than 80% control at 6 months after treatment (MAT). The only treatment providing 100% mortality 15 MAT was a ready to use formulation of triclopyr applied at 90 g L^{-1}. Research was continued in 2005 and 2006 on the Cimarron National Grassland located near Elkhart, KS to assess the effectiveness of herbicides applied to cut-stumps of saltcedar. In 2005, a stand of multi-stemmed saltcedar were cut near ground level during the dormant season using a 71-cm rotary saw attached on the front end of a tractor. On May 6, 2005, 100 cut-stumps were selected for herbicide treatment. Tree cutting and herbicide application occurred on April 26 in 2006. Ten or eleven treatments were applied each year in a randomized block design with 10 replications. Herbicides were applied using hand-held garden sprayers. Treatments applied in 2005 were rated for percent control 3 and 5 MAT, and for mortality 17 MAT. Treatments applied in 2006 were rated for percent control 4 and 6 MAT with a preliminary mortality rating taken 6 MAT. Treatments in 2005 and 2006 included an untreated check, triclopyr at 48 and 120 g L^{-1} diesel, glyphosate at 90 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 36 + 46 g L^{-1} water, glyphosate + imazapyr at 36 + 24 g L^{-1} water, and imazapyr at 23 g L^{-1} diesel. In 2006, an additional treatment of glyphosate at 180 g L^{-1} water was applied. All untreated trees resprouted, with resprouts up to 1.8 m tall. In 2005, all herbicides provided greater than 80% control 3 MAT except glyphosate at 90 g L^{-1} water. Additional resprouting occurred between 3 and 5 MAT. All treatments containing triclopyr or imazapyr provided greater than 80% control 5 MAT, except triclopyr + 2,4-D at 5 + 10 g L^{-1} diesel. The only treatments applied in 2005 providing 100% mortality 17 MAT were triclopyr at 120 g L^{-1} diesel and imazapyr at 23 g L^{-1} diesel. In 2006, all herbicide treatments except glyphosate at 90 g L^{-1} water provided at least 80% control of saltcedar 4 and 6 MAT. Apparent mortality at the end of the growing season was also 80 to 100% for these same treatments.

EFFECT OF ADJUVANTS OF THE EFFICACY OF AMINOPYRALID IN THE GREENHOUSE. David G. Ouse, F. Nelson Keeney and Keith Donley, Research Biologist Dow AgroSciences 9330 Zionsville Road Indianapolis IN, Advisor, Dow AgroSciences 9330 Zionsville Road Indianapolis IN and Technician, Dow AgroSciences 9330 Zionsville Road Indianapolis IN.

Greenhouse studies were conducted to determine if the addition of adjuvants to the spray mixture would significantly enhance the efficacy of aminopyralid. Treatments were evaluated on crested wheatgrass to determine if selectivity was affected, and five broadleaf weeds; field bindweed, Canada thistle, spotted knapweed, sicklepod and prickly sida, for activity enhancement. Adjuvants from several different categories; non-ionic surfactants, parafinnic oil, methyl or ethylated seed oil, organosilicone surfactant and ammonium sulfate fertilizer were tested with aminopyralid. A therapeutic index defined as the GR_{20} / average weed GR_{80} was used to identify treatments with good crop selectivity. An adjuvant index, defined as the average weed GR_{80} of aminopyralid alone / the average weed GR_{80} of aminopyralid + adjuvant, was utilized to identify adjuvants with the highest level of improvement in activity. A therapeutic index of $\geq$ 2 and an adjuvant index of $\geq$ 1.5 were identified as selection criteria for the best adjuvants for aminopyralid. Five adjuvants fit this critera, Sun-it II, Joint Oil, Silwett L-77, Trend 90 and Emery 33208. The best adjuvants from this group were recommended for further testing in the field.

AMINOPYRALID: GLOBAL OPPORTUNITIES FOR A NEW HERBICIDE. Robert A. Masters, John L. Troth, John J. Jachetta, Jeffery L. Jensen, Holger Tank, and Byron B. Sleugh, Dow AgroSciences, LLC, Indianapolis, IN 46268

Aminopyralid is a pyridine carboxylic acid herbicide developed for selective broadleaf weed control in rangeland, pastures, rights-of-way, non-cropland, natural areas, wheat, barley, sorghum, and oil palm and rubber plantations. Aminopyralid has very low acute and chronic toxicity (practically nontoxic) to mammals, birds, fish, and aquatic invertebrates, with no evidence of teratogenicity, mutagenicity, carcinogenicity, or adverse endocrine or reproductive effects. Aminopyralid is effective at rates between 53 and 120 g acid equivalent (ae) ha^{-1} in rangeland and pastures with little to no injury to many temperate and tropical grasses. It will be offered as a stand alone treatment or in pre-mix combinations with 2,4-D, fluroxypyr and triclopyr. Applied as a stand-alone treatment, aminopyralid controls key weeds in the genera *Ambrosia*, *Acacia*, *Carduus*, *Centaurea*, *Mimosa*, and *Rumex*, *Cirsium*, *Acroptilon*, *Senecio* and *Solanum*. Mixtures with the herbicides mentioned, will control a variety of added broadleaf weeds, including *Daucus carota*, *Lantana camara*, *Lespedeza* sp., *Ranunculus* sp., *Senna obtusifolia*, *Sida* sp., *Solidago* sp., *Symphoricarpos occidentalis*, *Taraxacum officinale*, *Urtica* sp., *Vernonia* sp. and *Vervain* sp. Product concepts in wheat are being developed in Argentina, Australia, Europe, Central and East Asia and USA. In wheat, aminopyralid will control *Fallopia convolvulus*, *Polygonum aviculare*, *Silybum marianum*, *Chrysantemum segetum*, and *Papaver rhoeas*. Aminopyralid plus glyphosate will be used in oil palm and rubber plantations to control key weeds including *Ageratum conyzoides*, *Asystasia intrusa*, *Hedyotis verticillata*, *Mikania cordata*, and *Paspalum conjugatum*. Aminopyralid use in oilseed rape and sugar cane are being evaluated. Registrations of aminopyralid-containing products are anticipated in more than 45 countries.

HERBICIDES FOR THE CONTROL OF GLYPHOSATE RESISTANT RYEGRASS. Marulak Simarmata*, Jan Michael, Donald Penner, Michigan State University, East Lansing, MI 48824.

Management of herbicide resistant weeds management is a subject of current interest. Worldwide, rigid ryegrass has developed resistance to numerous herbicides. Thus far only glyphosate resistance has been observed in rigid ryegrass from California. Rigid ryegrass from this source has a target site basis for resistance to glyphosate. The resistant biotype differs from the sensitive due to nucleotide substitutions that result in amino acid changes in the ESPS sequence. The objective of this study was to determine whether the glyphosate resistant biotype we have studied in the past is also resistant to other herbicides which might be used for control of this species. Greenhouse experiments compared control obtained with quizalofop, rimsulfuron + thifensulfuron, glufosinate, and glyphosate on glyphosate resistant and glyphosate sensitive rigid ryegrass. Control obtained with the quizalafop, rimsulfuron + thifensulfuron, and glufosinate on the glyphosate resistant and sensitive biotypes was similar, indicating that the glyphosate-resistant biotype could be controlled by herbicides with modes of action represented by the herbicides tested.

GLYPHOSATE DOSE-RESPONSE OF SELECTED INDIANA HORSEWEED BIOTYPES. Janelle M. Donahue, Vince M. Davis, Greg R. Kruger, and William G. Johnson, Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907-2054.

Glyphosate-resistant horseweed (*Conyza canadensis*) biotypes have been reported in 14 states. Populations from several states have demonstrated glyphosate tolerance in dose-response experiments. However, there is little information about the inheritance of variable levels of glyphosate tolerance in horseweed. The objective of this experiment is to determine if the rank in levels of glyphosate tolerance among first generation progeny corresponds to the rank in tolerance from respective maternal parents. Initial glyphosate screens were conducted on horseweed populations comprised of 40 composite mother plants. Resistant survivors that demonstrated varying levels of glyphosate tolerance were identified and allowed to self-pollinate. Seeds from individual plants were collected and grown in the greenhouse. Three experimental runs with plants 2 to 4 centimeters in diameter were sprayed with 0, 0.11, 0.21, 0.42, 0.84, 1.68, 3.36, 6.72, and 13.44 kg ae/ha of glyphosate and replicated 4 times. At 28 days after treatment (DAT), horseweed rosette widths were measured, individual plants were rated for visual control on a scale of 0 to 100, and plants were harvested for fresh and dry weight biomass production. The correlation between rankings of glyphosate tolerance levels from the mother plant to respective progeny was poor for most growth parameters. However, the ranking of glyphosate tolerance in the mother plants corresponded well with progeny survival at the 1.68 kg ae/ha rate. Mother plants with a “high” level of resistance had progeny survival of 92%, while a population with a “low” level of resistance had progeny survival of 25% at the 1.68 kg ae/ha rate.

RESISTANCE TO GLYPHOSATE AND ALS INHIBITORS IN INDIANA HORSEWEED BIOTYPES. Greg R. Kruger, Vince M. Davis, Valerie A. Mock, and William G. Johnson, Graduate Student, Research Associate, Graduate Student, and Associate Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Glyphosate resistant horseweed (GRH) has been found in 14 states including Indiana. In-field surveys conducted from 2003-2005 in Indiana found 26 counties with GRH. GRH was found to be prevalent in the southeastern region of Indiana. Horseweed populations resistant to ALS-inhibiting herbicides have also been reported in multiple states with Ohio reporting biotypes containing multiple glyphosate and ALS resistance. Previous experiments have also detected ALS resistant populations in selected Indiana horseweed populations. The objective of this experiment was to document the distribution of ALS resistance in horseweed biotypes across Indiana. During the in-field survey, horseweed populations were collected from random locations in 60 counties across the state, and screened for tolerance to chlorimuron and cloransulam-methyl with 1 oz ai ac^{-1} and 0.9 oz ai ac^{-1} respectively. Plants grown in the greenhouse were sprayed at 2.5 to 4 cm rosette widths and visual ratings on a 0 to 100 scale were collected 28 days after treatment. Resistant plants were defined as plants with visual rating less than 60% visual ratings. Approximately 20% of the populations were resistant to chlorimuron while approximately 10% of the populations were resistant to cloransulam-methyl.

COMPARING SHIKIMATE PRODUCTION IN GLYPHOSATE RESISTANT WEEDS. R. Douglas Sammons, Amanda Ohs, Robert Eilers, and William Gruenloh. Monsanto Co. 700 Chesterfield Parkway West, Chesterfield, MO 63017.

The conclusion that a particular weed is resistant to glyphosate is important to a weed management program. A definitive procedure is recommended at www.weedscience.com however, the steps outlined there can take considerably more time then a current weed problem allows for a best weed control option. Several reports (Shaner et al. 2005, Koger et al. 2005) describe a quick determination of shikimate in leaf samples as a means to identify glyphosate resistance. The idea being that surviving weeds might be quickly assayed to determine if they are glyphosate resistant so an appropriate follow-up treatment can be prescribed. The assay reported is fairly simple using a colorimetric assay developed by Cromartie and Polge 2002. The method relies on glyphosate inhibition to create high levels of shikimate (or not for resistant plants) which are extracted and then quantified by chemical conversion to a unique chromophore absorbing at 382 nm. We were interested in whether this method would work for weeds that are weakly resistant to glyphosate e.g., goosegrass (Malaysia) or Italian ryegrass (Chile) where control can be achieved with 2-3 times the label rate of glyphosate (1.6-2.4 kg ae ha^{-1}). Secondly, we wanted to see if the method was generally applicable to various species where the resistance level is higher e.g. in the 6-10 times the labeled rate range (4.8-8 kg ae ha^{-1}). Finally, we examined glyphosate dose and shikimate production with respect to time and confirmed all colorimetric measurements by HPLC analysis directly (Lydon and Duke 1988). The HPLC method isolates shikimate from the crude extract directly as a single compound identifiable by its UV spectrum at 210-240 nm.

The colorimetric assay gave mixed results compared to the HPLC method. In a well behaved system, for example horseweed, the colorimetric assay was similar to the HPLC result in the range up to 2.0 absorbance units. Some plant extracts however, were not well behaved. For example; Chilean Italian ryegrass (and goosegrass too) had variable glyphosate induced shikimate production which was not stable with time for several dose regimes in the 1-100 mg glyphosate ae L^{-1}. Italian ryegrass had a colorimetric impurity that was significant enough to prevent simple blank subtraction and there was also significant shikimate present in untreated plants. *Amaranthus* samples were variable with some plants containing a colorimetric impurity and others did not while background shikimate could be found in some untreated plants. This variability of shikimate background in untreated control plants did not correlate to glyphosate sensitivity or resistance.

In conclusion, the colorimetric assay can be used on some species if several precautions are observed. There are important variables in the glyphosate incubation with respect to buffer where 2-(4-morpholino)-ethane sulfonate (MES) made resistant horseweed leaf dics behave as if they were sensitive. Whereas the recommended ammonium phosphate buffer made all leaf samples more tolerant to glyphosate. Further, the fold resistance and dose interact with time (or light quality) so that incubation period must be lengthened to 48 hours for more certain results. With respect to shikimate analysis; species with high backgrounds of a colorimetric contaminant or background shikimate will be problematic. In these studies Italian ryegrass from Chile (2-3X label rate) and Brasil (6-8X label rate) could not be definitively labeled resistant or sensitive. Secondly, *A. palmerii* contained shikimate in untreated plants making a definitive test difficult. Thirdly some species, Johnsongrass (Argentina) had variable background shikimate and/or colorimetric contaminants such that individual plants were unique making it difficult to compare plants and determine glyphosate sensitivity.

Shaner, D. L., T. Nadler-Hassar, W. B. Henry, and C. H. Koger. 2005. A rapid in vivo shikimate accumulation assay with excised leaf discs. Weed Sci. 53:769-774.

Koger, C. H., D. L. Shaner, W. B. Henry, T. Nadler-Hassar, W. E. Thomas and J. W. Wilcut. 2005. Assessment of two nondestructive assays for detecting glyphosate resistance in horseweed (Conyza Canadensis). Weed Sci. 53:559-566.

Lydon, J and S. O. Duke. 1988. Glyphosate induction of elevated levels of hydroxybenzoic acids in higher plants. J. Agric. Food Chem. 36:813-818.

Cromartie, T. H. and N. D. Polge. 2002. Method of detecting shikimic acid. United States Patent 6,482,654.

SIMULATED GLYPHOSATE DRIFT IN POTATO (*SOLANUM TUBEROSUM*) AT DIFFERENT GROWTH STAGES. Collin P. Auwarter and Harlene M. Hatterman-Valenti, Research Specialist and Assistant Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Previous research has shown that simulated glyphosate drift to seed potato (*Solanum tuberosum* L.) late in the growing season causes virtually no visible injury symptoms but can influence sprouting of daughter tubers and in return reduce yield. However, questions remain as to whether glyphosate drift during late tuber bulking is the most sensitive potato growth stage. The objective of this study was to compare the injury from glyphosate applied to Red Lasoda potatoes at the tuber set stage (TS) and early bulking stage (EB) to the late tuber bulking/early senescence stage (LB). Glyphosate was applied at rates one-third, one-sixth, one-twelfth, and one-twenty-fourth the standard use rate (0.25, 0.125, 0.0625, and 0.0313 lb ae/A) on July 18 and August 14 and at the 0.25 lb ae/A rate on September 11 with a CO2 pressurized sprayer equipped with 8002 flat fan nozzles with a spray volume of 30 GPA and a pressure of 40 psi. The amount of AMS added to the spray solution was also reduced accordingly.

Potatoes treated with 0.25 lb/A glyphosate at the EB stage produced significantly more tubers than other treatments. However, this was primarily due to the greater number of cull tubers (≤ 4 oz). Potatoes treated with 0.25 lb/A glyphosate at the EB stage produced 40% more cull tubers than potatoes treated with 0.125 lb/A glyphosate at the EB stage and 2.5 times more culls tubers than the untreated check.

Potatoes treated with glyphosate earlier during the growing season (TS or EB) had lower yields compared to those treated with the same rate at the later growth stage (LB). Plants treated with ≤ 0.0625 lb/A glyphosate at the TS or EB growth stages or with 0.25 lb/A glyphosate at the LB stage had total yields similar to the untreated check. Plants treated with 0.25 lb/A at TS or EB, and plants treated with 0.125 lb/A glyphosate at the EB stage consistently yielded higher for cull tubers and tubers graded at the 4 to 6 oz. size, whereas they consistently yielded less for grades 6 to 10 oz, 10 to 12 oz, and > 12 oz sizes.

Daughter tubers are being stored throughout the winter to determine if daughter tubers from plants treated with glyphosate at the TS and EB stages will be affected similar to those daughter tubers from plant treated with glyphosate at the LB stage.

CHANGES IN WEED C0MMUNITIES DURING TRANSITION TO ORGANIC PRODUCTION.
Isabel Rosa and John Masiunas, Graduate Research Assistant and Associate Professor, Department of Natural Resources and Environmental Sciences, University of Illinois, 1201 W. Gregory Dr., Urbana, IL 61801.

Emerged and soil seed bank populations of weeds undergo major changes during the transition from conventional to organic cropping systems. Often weed densities increase during the transition and stabilize or decrease after a period in organic production. We hypothesized that management intensity and soil amendments will impact weed communities. In 2003, we established three management intensities, intense vegetable crop production, medium intensity grain crop production and low intensity ley production. The three soil amendment strategies were cover crops only, cover crops and compost, and cover crops with manure. The experiment was a randomized block design in a split plot arrangement with four replications. Between 2003 and 2006, the number of weeds per plot decreased. In 2003, the dominant weed species were grasses in the ley; common lambsquarters and velvetleaf in the grain crop; and lambsquarters, grasses, and foxtails in the vegetable. In 2003, the ley system had the most weeds in subsequent years it had fewer weeds than other management intensities. In 2004 and 2005, the grain system had more weeds than the vegetable system. The higher returns for vegetable production allowed hand-weeding which likely reduced weed populations compared to the cash grain system. The effect of soil amendment varied depending on year. In 2004, there were more weeds in the manure amendment and in 2005 there were more weeds in the cover crop only amendment. Weed species composition changed depending on management intensity and year. Common lambsquarters became less frequent, mainly due to later plantings. *Amaranthus* species (primarily redroot pigweed) became more frequent. Common purslane, a problem weed of vegetables, first was found in Brassica vegetables in 2005. Weed species diversity in the seed bank increased between 2003 and 2005. Species composition of the seed bank was similar to the composition of the emerged weed community with the exception that seed from *Amaranthus* species were the most common. A managed ley system may be a method for land-rich farmers to transition to organic production without increases in weed populations.

EFFECTS OF A SULFOMETURON-METHYL AND HEXAZINONE BLEND ON WEED CONTROL IN EASTERN CHRISTMAS TREE PRODUCTION. Marsha J. Martin, Susan K. Rick, and Ronnie G. Turner. Development Representative, Columbus, OH 43235, Development Representative, Waterloo, IL 62298 and Product Development Manager, Memphis, TN 38125. DuPont Crop Protection.

In 2006, testing of a 6.5% sulfometuron-methyl and 68.6% hexazinone premix (Westar™) continued in eastern Christmas tree production. Westar™, a water-dispersible, granular-blended herbicide was tested at 10 locations in CT, IL, MD, MI, NC, NY, OH, PA and WI, and at 4 rates, 4.51, 6.01, 7.51 and 9.01 oz ai/ac. Traditional small plot field techniques were employed and applications were made to dormant trees in the early Spring. 2006 crop safety results were excellent, predominantly zero injury on most Christmas tree types at most locations. In 5 tests for Frasier Fir, maximum average injury was 3%. In 3 tests for Colorado Blue Spruce, maximum average injury was 2.5%. In 4 tests for Douglas Fir, maximum average injury was 5% and for the 1 White Pine test, there was no injury. Tree ages ranged from 1 year to 8 years after field planting. 2006 efficacy results at 55 to 80 days after application for all 4 Westar™ herbicide rates showed excellent control (98-100%) of common ragweed, lambsquarters, large crabgrass, panicum species, foxtail species and dandelion. For quackgrass, yellow nutsedge and marestail, excellent control was seen at higher rates with fair to good control at lower rates. All 4 rates of Westar™ herbicide gave better control of quackgrass, yellow nutsedge, marestail and foxtail than 4 to 6 oz ai/acre flumioxazin, but on common ragweed, lambsquarters, large crabgrass, panicum and dandelion, Westar™ herbicide and flumioxazin gave similar results. Efficacy evaluations made between 85 and 120 days after application showed a similar pattern with all rates of Westar™ herbicide giving good to excellent control of common ragweed, lambsquarters, large crabgrass, marestail, panicum, foxtails, and dandelion. Yellow nutsedge and quackgrass showed the most dose response with the higher rates needed for good control.

TOLERANCE OF SWEET CORN TO TOPRAMAZONE. Darren E. Robinson, John O'Sullivan, John Zanstra, Nader Soltani and Peter H. Sikkema, Assistant Professor, Professor, Research Associate and Assistant Professor, Department of Plant Agriculture, University of Guelph, Ridgetown, ON, N0P 2C0.

Topramezone is a newly introduced herbicide for use in field corn (*Zea mays* L.), and may have use as a postemergence treatment in sweet corn. Tolerance of eight hybrids of sweet corn to topramezone applied postemergence (POST) at rates of 0, 50, 75, 100, 150 and 300 g ai ha^{-1} were studied at one Ontario location in 2000, and two locations in 2001 and 2002. Topramezone applied POST at 50, 75, 100 and 150 g ha^{-1} did not cause any visual injury in Calico Belle, CNS 710, Delmonte 2038, FTF 222, FTF 2467, GH 2684, Reveille, and Rival sweet corn hybrids at 7 days after treatment (DAT) and caused minimal injury (less than 5%) at 300 g ha^{-1} in all hybrids. The initial sensitivity observed in these hybrids was minimal and transient with no effect on visual injury at 14 and 28 DAT. Topramezone applied POST at 50, 75, 100, 150 and 300 g ha^{-1} did not reduce plant height, cob size, and marketable yield of Calico Belle, CNS 710, Delmonte 2038, FTF 222, FTF 2467, GH 2684, Reveille and Rival sweet corn hybrids. Based on these results, we conclude that topramezone applied POST at rates evaluated can be safely applied to Calico Belle, CNS 710, Delmonte 2038, FTF 222, FTF 2467, GH 2684, Reveille and Rival sweet corn.

TOLERANCE OF FOUR POPCORN HYBRIDS TO BAS 799 H. Thomas T. Bauman and Michael D. White, Professor and Research Associate, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

A field trial was conducted in 2006 to test the tolerance of four popcorn hybrids to dicamba (dimethylamine salt), dicamba+diflufenzopyr and BAS 799 00H. These herbicides were sprayed 23 days after planting to V-3 stage popcorn that was 8 inches tall. Dicamba DMA was applied at 0.5 lb ai/a. Dicamba+diflufenzopyr and BAS 799 00H were both applied at 0.35 lb ai/a. Non-ionic surfactant (0.5%) and ammonium sulfate (10 lb/100 gal) were added to all herbicide treatments. Spray volume for all post-emergence treatments was 20 gpa. Plots were maintained weed free for the entire growing season with a pre-emergence application of dimethenamid+atrazine (2.5 lb ai/a) and mechanical cultivation.

The four hybrids differed greatly in their response to the different herbicides.

Epinasty – All four hybrids showed symptom 4 days after treatment for all herbicides. Injury was less severe with BAS 799 00H than with dicamba+diflufenzopyr or dicamba DMA. Symptom persisted the entire season on one hybrid when treated with dicamba DMA. Symptom was not observed on three of the hybrids 14 DAT.

Stand Reduction – A 25% reduction in popcorn stand of one hybrid was observed with the DMA formulation. No reduction in stand was observed with any other herbicide or hybrid.

Stunt – Dicamba DMA caused stunting of one hybrid. No reduction in crop height was observed with any other hybrid or herbicide.

Goose-neck – Symptom was observed 12 DAT with three hybrids. Injury was more severe with dicamba DMA and dicamba+diflufenzopyr than with BAS 799 00H.

Root Malformation – Symptom was observed in of the hybrids. Trend was for it to be less severe with BAS 799 00H than with dicamba DMA or dicamba+diflufenzopyr.

Grain Yield – Significant differences in yield was observed only in one hybrid. Yield from weed free and BAS 799 00H were higher than those treated with dicamba DMA or dicamba+diflufenzopyr. The trend for the other hybrids was untreated > BAS 799 00H > dicamba+diflufenzopyr > dicamba DMA.

USING SPECTRAL VEGETATION INDICES FOR WEED DETECTION 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 are grown as high value essential oil crops in the Midwestern U.S. (IN, MI, and WI) and the Pacific Northwest (OR, WA, MT, and ID). Remote sensing-based site-specific weed management offers great potential to decrease weed control costs by simplifying weed detection and producing site specific herbicide application maps. In order to automate the process of turning a remotely sensed image into an herbicide application map, some type of spectral identifier is needed that can be used to differentiate weed-free pixels from weedy pixels. Our past research has developed spectral vegetation indices (SVIs) for differentiating mint and key weed species. Our objective in these studies was to apply SVIs calculated from handheld spectroradiometer reflectance data to reflectance data calculated from airborne hyperspectral images to determine which method had the highest accuracy for differentiating between mint and weeds in the image. Airborne imagery is the fastest and most economical method to obtain reflectance data for production fields, but absolute reflectance can vary between images. SVI calculations were made from experimental field plots of peppermint, spearmint, giant foxtail, white cockle, tall waterhemp, Powell amaranth, common lambsquarter, and velvetleaf. SVIs based on simple ratios of reflectance values in the near infrared and green portions of the spectra accurately differentiated between peppermint and weed species, while simple ratios of near infrared and red reflectance values accurately differentiated between spearmint and weed species. The ratio of mint to weed SVI values was approximately 2 to 1 in both instances even though the absolute values of SVIs varied between spectroradiometer and image calculations. The 2X difference in SVI values can be used to identify weedy areas of a mint field in a hyperspectral image and allow accurate targeting of postemergence herbicide applications which would reduce costs and increase efficiency of weed management for growers.

FULL- AND SPLIT-RATES OF *S*-METOLACHLOR AND DIMETHENAMID-P FOR LAY-BY APPLICATIONS IN SUGARBEET. Scott L. Bollman and Christy L. Sprague, Graduate Research Assistant and Assistant Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Field trials were conducted in East Lansing, MI in 2004 and 2005 and in St. Charles, MI in 2004, 2005, and 2006 to compare weed control and sugarbeet tolerance from the addition of *s*-metolachlor and dimethenamid-P to sugarbeet micro-rate herbicide applications. Herbicide treatments consisted of a base micro-rate herbicide treatment of desmedipham and phenmedipham at 90 g/ha + triflusulfuron-methyl at 4.4 g/ha + clopyralid at 26 g/ha + methylated seed oil at 1.5% v/v applied four times at 125 growing degree days (base 1.1 C) intervals. Micro-rate treatments were applied alone and in different combinations with *s*-metolachlor or dimethenamid-P. Total *s*-metolachlor and dimethenamid-P application rates were 1.4 and 0.84 kg/ha, respectively. The different treatments consisted of the full *s*-metolachlor or dimethenamid-P rate applied PRE or in one of each of four micro-rate herbicide application timings, split-applications of each herbicide at PRE and the third micro-rate, first and third micro-rate, or in the second and fourth micro-rate herbicide application. Additional treatments included *s*-metolachlor or dimethenamid-P applied at a quarter of the full-rates in each of the four micro-rate herbicide applications. All treatments resulted in sugarbeet injury. In 2004 and 2006, full-rates of both *s*-metolachlor and dimethenamid-P applied PRE and in the first micro-rate caused significantly greater injury than the base micro-rate. When the applications were split between PRE and the third micro-rates or between the first and the third micro-rates, *s*-metolachlor and dimethenamid-P also caused greater sugarbeet injury than the base micro-rate treatment. In addition, applying the quarter rate of dimethenamid-P in four micro-rates also caused significant sugarbeet injury. Applying either *s*-metolachlor or dimethenamid-P at the full-rates in either the third or fourth micro-rate timings or splitting the applications between the second and fourth micro-rates did not increase injury over the base micro-rate treatment. Control of common lambsquarters and giant foxtail from all treatments containing *s*-metolachlor or dimethenamid-P, regardless of time of application, was greater than the base micro-rate treatment at all locations. *Amaranthus* spp. control was 94% or greater from all treatments. In 2004, control of late-season giant foxtail was greater in all treatments that included *s*-metolachlor or dimethenamid-P compared with the base micro-rate treatment. In 2005, the only treatments that did not improve control of giant foxtail later in the season compared to the base micro-rate treatment were the treatments that included a full-rate of *s*-metolachlor or dimethenamid-P applied in the fourth micro-rate. Even though there were treatments that caused greater sugarbeet injury compared with the base micro-rate treatment, there were no differences in recoverable white sucrose yield at the end of the season.

EFFECT OF LATE-SEASON GLYPHOSATE DRIFT TO SEED POTATO. Harlene M Hatterman-Valenti*,Collin P Auwarter, and Paul G Mayland, Assistant Professor, and Research Specialists, Plant Sciences Department, North Dakota State University, Fargo, Fargo, ND 58105.

A field trial was initiated during 2004 at a NDSU Agriculture Experiment Station dryland site near Prosper, ND to evaluate the effect of simulated drift from glyphosate to Russet Burbank and Red Lasoda seed potato during early the early senescence stage. Glyphosate was applied at rates one-third, one-sixth, one-twelfth, one-twenty-fourth, and one-forty-eight the harvest aid rate for spring wheat on on September 10, 2004 and September 2, 2005 with a CO2 pressurized sprayer equipped with 8002 flat fan nozzles with a spray volume of 30 GPA and a pressure of 40 psi. The amount of AMS added to the spray solution was also reduced accordingly. Following harvest, samples from each plot were placed into cold storage until the following March. A subsample from each plot was slowly warmed to initiate sprout formation and the visual evaluation of bud break. The remaining samples were cut into 2 oz pieces with at least two eyes to each piece; dusted with a seed piece treatment, and stored at 65º F with approximately 90% RH until planted. Plots consisted of two 10 ft rows at 36 inch row spacing with a border row on each side and three spacer plants between plots. The trial was arranged as a randomized complete block with four replications. Extension recommendations were used for cultural practices. Plots were desiccated on September 5 and 12, 2005 September ? and ?, 2006. Plot harvest occurred September 21, 2005 and September ?, 2006. Tubers were graded into the various categories shortly after harvest.

Results indicated that glyphosate at 0.0625 lb ae/A or more inhibited tuber bud break by 75% or more compared to untreated. In the field, injury was observed as delayed emergence and in several instances, no plants emerged. In the instances where no plants were present, seed pieces had numerous short sprouts at each eye that never elongated beyond 2 inches in length. Only tubers from the Total yield in 2005 for Red Lasoda was 311 cwt/A for the untreated, which was significantly greater than glyphosate treatments of 0.25, 0.125, and 0.0625 lb ae/A. Yield of tubers ≥ 4 oz were similar indicating that the injury suppressed tuber initiation and bulking. Russet Burbank total yield was considerably less at 210 cwt/A for the untreated. Both the untreated and glyphosate at 0.0156 lb ae/A had significantly greater total yields compared to glyphosate treatments of 0.25, 0.125, and 0.0625 lb ae/A. Number of tubers ≥ 4 oz data indicated that yield reduction was due to decreased tuber initiation (resorption or tubers smaller than spaces in harvest belt) and decreased tuber bulking. Yield data in 2006 mimicked those of 2005. Results show that even though visible injury symptoms where not obvious following glyphosate treatment, significant injury to daughter tubers can occur. This injury may not be visible until tuber sprouting is to occur.

INTEGRATED SWAMP DODDER MANAGEMENT IN CARROT PRODUCTION.
Christopher M. Konieczka and Jed B. Colquhoun, Graduate Research Assistant and Extension Weed Specialist, Department of Horticulture, University of Wisconsin, 1575 Linden Drive, Madison, WI 53706.

Swamp dodder (*Cuscuta gronovii)* continues to spread through Wisconsin carrot production, reducing crop yield and quality. Studies were conducted in a naturally infested field to evaluate the effects of mowing and herbicides on swamp dodder. Mowing timings included 58, 72, 86, 100, and 72 + 100 days after planting (DAP). Data collection included visual evaluations of carrot injury and swamp dodder control, quantification of swamp dodder infected carrots, and carrot yield. Mowing 58 or 72 DAP did not decrease swamp dodder infection compared to the unmowed treatment. Carrot mowing 100 DAP reduced swamp dodder infection approximately 93%. Carrot yield was similar to the unmowed control in all treatments. Carrot injury was minimal where pendimethalin, oxyfluorfen, or flufenacet were applied. Swamp dodder control was greater than 80% where rimsulfuron or flucarbazone were applied, however crop injury from rimsulfuron was excessive. Carrot yield was similar to the untreated control in all treatments, except where pendimethalin or diquat were applied, where yield was greater than the untreated control. Future research will integrate mowing and herbicide treatments for improved swamp dodder control.

JUNEBERRY GROWTH AS AFFECTED BY WEED CONTROL METHODS. Deborah A. Willard and Harlene Hatterman-Valenti, Graduate Student and Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

A study was conducted during 2005 and 2006 in a field near Prosper, ND to determine the efficacy of various weed control methods on juneberry (*Amelanchier alnifolia*) growth. The juneberry cultivar, Parkhill was tested in this experiment. The plants were produced from stratified seed in the spring of 2004. They were grown outdoors in containers until fall. In October 2004 they were placed in a cold storage facility at 4.4^{o}C. They were removed from cold storage in mid-March 2005 and maintained in the greenhouse at 21 to 24^{o}C. On May 19, 2005 they were moved outdoors to a protected area to harden-off for 2 wk prior to being transplanted to the field on June 2, 2005. The experiment was arranged as a randomized complete-block design. There were eight weed control treatments and four replicates. Each single row plot measured 0.9 m wide and 6.7 m long and contained 10 plants. Plant spacing was 0.6 m with 1.2 m between treatments. Each replicate was 53.7 m long and contained 80 juneberry shrubs with 4.3 m between replicates. Each treatment was applied to a 0.9 m wide section of each row, extending 0.5 m on either side of the juneberry row. Treatments consisted of: 1) winter rye (*Secale cereale* L.) cover crop, 2) hairy vetch (*Vicia villosa*), 3) flax (*Linum usitatissimum)* mulch 4) straw mulch, 5) landscape fabric, 6) linuron Year 1 and flumioxazin thereafter, 7) glyphosate plus oryzalin, and 8) untreated control that received hand-weeding three times during each year of the experiment. Winter rye was sown in September of 2004 and 2005 at 342 kg/ha. Hairy vetch was sown in the spring of 2005 and 2006 at 61.2 kg/ha. In 2005, wheat straw was spread to a uniform depth of 7 cm and flax mulch and landscape fabric were laid down with a 5-cm diameter hole and 15-cm slit for each plant, respectively. Herbicide treatments were applied twice each growing season.

Woven landscape fabric was the most effective in eliminating weed emergence, whereas, winter rye cover crop allowed significantly more weeds to emerge throughout the study. Both years, a hairy vetch companion crop provided poor early to mid-season weed control, yet fair to good late season weed control. However, the hairy vetch was very competitive with the crop, and therefore, significantly reduced juneberry height, width, stem number and length of main and secondary branches. Herbicide treatments and the untreated control resulted in the most juneberry growth. This research supports using woven landscape fabric to eliminate weed emergence in juneberry orchards. However, to produce the tallest juneberries with the greatest width, stem number, and length of main and secondary branches, glyphosate plus oryzalin or linuron should be used to control weeds.

FALL AND SPRING DEVELOPMENT OF SOYBEAN CYST NEMATODE ON WINTER ANNUAL WEEDS. J. Earl Creech, William G. Johnson, Jared S. Webb, Bryan G. Young, Jason P. Bond, and S. Kent Harrison, Graduate Research Assistant and Associate Professor, Purdue University, West Lafayette, IN 47907, Graduate Research Assistant, Associate Professor, and Assistant Professor, Southern Illinois University, Carbondale, IL 62901, Professor, the Ohio State University, Columbus, OH 43210.

Certain winter annual weeds have been confirmed as alternative hosts to soybean cyst nematode (SCN) in the greenhouse. However, SCN development is known to cease at temperatures below 10 C. Thus, the potential interaction between winter weeds and SCN in the field is limited to a short period of time in the fall and the spring when both the nematode and the weeds are present and active. SCN reproduction on purple deadnettle was recently confirmed at one site in southern Indiana. The objective of this research was to determine the distribution of SCN development and reproduction on winter annual weeds in the North Central region. To address this objective, surveys were conducted in Illinois, Indiana, and Ohio in which three sampling sites were chosen in each state to represent a range of environmental conditions. Fall sampling occurred in mid-December of 2004 and 2005 while spring sampling occurred in early-May of 2005 and 2006. Five purple deadnettle or henbit plants were removed from five locations within each field and transported to the laboratory where SCN juvenile, cyst, and egg counts were performed. SCN reproduction occurred more frequently and at higher levels in the fall than the spring and was generally highest at the most southern field sites. SCN juvenile presence was generally higher in the spring than the fall. Thus, SCN reproduction in the eastern Corn Belt appears to be widespread and SCN management programs in fields with high populations of henbit or purple deadnettle may require a winter weed management component. In addition, delaying burndown of winter annual weeds until mid-May or later could allow spring-hatching SCN juveniles sufficient time to complete a life-cycle and further enhance the effect these weeds have on SCN population density.

THE RELATIONSHIP OF SOYBEAN CYST NEMATODE AND PURPLE DEADNETLLE MANAGEMENT IN MICROPLOTS. Jared S. Webb, Bryan G. Young, and Jason P. Bond, Graduate Research Assistant and Associate Professors, Department of Plant, Soil, and Ag systems, Southern Illinois University, Carbondale, IL 62901.

Soybean cyst nematode (SCN, *Heterodera glycines*) can reproduce on the winter annual weed species purple deadnettle under field and greenhouse conditions. Purple deadnettle has been shown to be an effective host of SCN under greenhouse conditions. Hosts such as purple deadnettle may allow the SCN population to increase in the absence of soybean. The relationship of SCN reproduction on winter annual weeds has not been well documented under field conditions. Therefore, field microplots were established in Carbondale, IL during the 2005 and 2006 growing seasons to characterize the reproduction of SCN on purple deadnettle under simulated field conditions and determine what influence winter annual weed management strategies have on the SCN population. Removal strategies for purple deadnettle consisted of either removal by herbicide or tillage in the fall or spring. Glyphosate was used at 840g ae/ha for control of purple deadnettle by herbicide.

SCN were found to infect the roots of purple deadnettle during both years of the experiment. However, reproduction of SCN was only found to occur during one year of the experiment. Reproduction occurred at a very minimal level and would not justify concern from producers. SCN cysts/100cm^3 soil and eggs/100cm^3 soil were not influenced by the presence of purple deadnettle during either year of the experiment. There were no differences in cysts/100cm^3 soil or eggs/100cm^3 soil from any purple deadnettle removal strategy. These results indicate that growers should not be concerned with managing purple deadnettle to restrict SCN population growth. However, more research is justified to determine the influence of SCN HG type on the host compatibility of purple deadnettle. This experiment was conducted with SCN HG type 2.5.7 (race 5), which has not been previously tested for purple deadnettle host compatibility.

INVESTIGATION OF WEED SUPPRESSION POTENTIAL OF POLYMER-INDUCED SOIL CRUSTING. Justin D. Valletta, Edward C. Luschei and Chris M. Boerboom, Undergraduate and Professors, Agronomy Weed Science Department, University of Wisconsin, Madison, WI 53706.

Natural soil crusting can impede both crop and weed emergence. If we could selectively induce crusts that impede weeds but not crops, such artificial crusting would have great weed control value. Such a crust could replace a variety of mulches and the problems associated with them.

Greenhouse and field studies have been conducted to evaluate the potential of a polymer induced soil crust weed barrier. Soil Net LLC, developed the polymer formulation in this study (SN2500). Greenhouse experiments were conducted to look at the relationship between carrier volume and concentration of SN2500 on soil crust strength. In the field study, four crops were seeded into a sandy pivot-irrigated soil and the soil was treated with various combinations of concentrate and carrier volume.

In the greenhouse we tested five concentrations (20%, 40%, 60%, 80%, and 100%) of a SN2500 liquid concentrate at (200, 400, 800, 1200, and 1600 gal/acre). Concentrations at 60% or higher with a volume of at least 800 gal/acre produced the best results. From these greenhouse studies, rates and carrier volumes were tested in the field.

Polymer was applied to square meter plots that were planted with wheat, alfalfa, onion, beat, or nothing planted. Some suppression can be seen in the higher carrier volume rates along with a higher concentration of SN2500. The field tests showed that we were able to form a crust with the polymer in field conditions, but application rates were high and the suppression of emergence was marginal. There also appears to be sufficient variation in the crust that allows weeds to successfully emerge.

WEED COMMUNITY COMPOSITION OVER EIGHT YEARS OF CONTINUOUS GLYPHOSATE USE IN A CORN-SOYBEAN ANNUAL ROTATION. Mark R. Jeschke and David E. Stoltenberg, Graduate Research Assistant and Professor, Department of Agronomy, University of Wisconsin, Madison, WI, 53706.

Field research was conducted from 1998 through 2005 to determine the effects of primary tillage system and glyphosate use intensity on weed community composition in a corn-soybean annual rotation. Six weed management treatments were compared across three tillage systems: moldboard plow, chisel plow, and no-tillage. Weed management treatments were based on six levels of glyphosate use intensity: glyphosate applied postemergence (POST), glyphosate applied POST and late POST (in corn only), 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 preemergence (PRE) followed by glyphosate applied POST, and a non-glyphosate program. Plots (6.1 m by 12.1 m) were maintained in the same location for the duration of the experiment. Weed seedbank density was measured prior to crop planting and weed plant density was measured several times each growing season. Weed plant density and species richness were typically lower in the moldboard plow system than in the chisel plow and no-tillage systems. Weed species richness was typically greater in glyphosate-based weed management treatments than in non-glyphosate treatments, in which a few highly competitive species became dominant over time. Weed community composition was affected little by most glyphosate-based treatments, with common lambsquarters, giant foxtail, and pigweed species remaining the most abundant species over time. Similarly, total weed density in glyphosate-based treatments changed little or decreased over time. However, in treatments where weed management consisted of glyphosate applied POST only once, giant ragweed, shattercane, and large crabgrass plant densities and seedbank densities increased over time, particularly in the chisel plow and no-tillage systems; however, increased densities of these species had little effect on total weed seedbank density. Although only minor changes in weed community composition associated with glyphosate use intensity occurred over 8 yr, an extended emergence period may be a key mechanism by which weed populations persisted or increased over time.

BIOMASS ALLOCATION PATTERNS OF FIELD-GROWN COMMON LAMBSQUARTERS AND GIANT FOXTAIL AS AFFECTED BY EARLY-SEASON VARIATION IN LIGHT QUALITY. Greta G. Gramig and David E. Stoltenberg, Graduate Research Assistant and Professor, Department of Agronomy, University of Wisconsin, Madison, WI, 53706.

Field experiments were conducted in 2004 and 2005 to determine if early-season exposure of common lambsquarters (CHEAL) and giant foxtail (SETFA) to reduced R:FR ratios, mediated by neighboring corn plants and without shading, are associated with either early- or mid-season changes in biomass allocation. CHEAL and SETFA were grown in 11.4-L pots and exposed to reduced (0.2-0.4) or ambient (0.8-1.0) R:FR ratios by placing pots between rows of corn or on bare soil. Within these treatment areas, R:FR ratios and light quantity were maintained by removing and trimming corn and controlling weeds. About 4 wk after emergence (WAE), a subset of target plants was harvested from each treatment area to determine early-season light quality effects. Remaining plants were placed either in partial shade or in full sunlight. About 3 wk after pots were moved (7 WAE), a subset of plants was sampled as above. Analysis of variance and specific contrasts were used to assess treatment effects on biomass allocation to leaves, main-stems, tillers or branches, reproductive organs, and roots. For CHEAL and SETFA exposed to reduced early-season R:FR ratios (without shade), specific stem length (SSL), specific leaf area (SLA), and main-stem:branch or tiller biomass allocation (SETFA 2005 only) were greater than for plants exposed to ambient R:FR ratios. When exposed to full sunlight during mid-season (4-7 WAE), main-stem:branch biomass allocation was greater for CHEAL exposed to reduced than ambient early-season R:FR ratios. However, when exposed to partial shade during mid-season, biomass allocation patterns did not differ between CHEAL exposed to reduced or ambient early-season R:FR ratios. For SETFA exposed to full sunlight during mid-season, reduced early-season R:FR ratios were associated with less root:shoot biomass allocation compared to plants exposed to ambient early-season ratios. SETFA exposed to reduced early-season R:FR ratios and mid-season partial shade had greater main-stem:tiller biomass allocation than SETFA exposed to ambient early-season ratios and mid-season partial shade. These results suggest that, while early-season exposure to reduced R:FR ratios may increase the short-term competitive ability of these species, such exposure does not appreciably alter responses to later changes in the light environment.

EXPERIMENTAL CYLINDER COMPARISONS FOR MONITORING SEEDLING EMERGENCE. Kurt Spokas, Frank Forcella, David Archer, and Dean Peterson, Soil Scientist, Research Agronomist, Agricultural Scientist, and Agricultural Science Research Technician, USDA-Agricultural Research Service, Morris, MN 56267.

PVC cylinders are used routinely to examine weed seed bank dynamics. Recent observations in our field experiments led us to examine the impacts of artificial barriers, like PVC, on the soil microclimate conditions within weed emergence trials. Barriers examined in this study were: (a) PVC, where soils inside and outside were separated completely; (b) aluminum window screen, where soils inside and outside were connected partially; and (c) an auger hole refilled with soil, but with no artificial barrier. Microclimate conditions were monitored inside and outside of the barriers. Soil temperatures were monitored at 1, 2, 3, 4, 5, 6, 7, 9, 11, 15 and 20 cm, whereas soil moisture was monitored only at 2, 5, and 10 cm in each treatment. Soil moisture potentials inside of the PVC cylinders were typically higher than those for outside soils and screened soils. This indicated more soil moisture available to weed seeds inside of the PVC cylinder than outside, with a maximum observed deviation of 0.4 MPa among the various treatments. Temperature differences possessed a diurnal pattern, where the maximum difference in temperature occurred near solar noon (max 17 C difference at 1 cm), with the PVC cooler than the undisturbed soil. At night, the PVC-enclosed soil was warmer, with a maximum deviation of 8 C at 1 cm. Temperature differences lessened with depth, and at 20 cm no differences occurred among treatments and time. These temperature differences could be a result of the differences in soil moisture, since thermal conductivity is a function of water content. This impact on the microclimate conditions also impacted weed seedling emergence. Seedlings of giant foxtail (*Setaria faberii*), velvetleaf (*Abutilon theophrasti*), and wild oat (*Avena fatua*) emerged similarly from within screened soils and the soil-only barriers, whereas the emergence within PVC cylinders was delayed by approximately 7 days. These results will aid other researchers in devising more effective protocols for experiments involving weed seed bank dynamics.

GLYPHOSATE-RESISTANT HORSEWEED POPULATION DYNAMICS ARE INFLUENCED BY INTEGRATED WEED MANAGEMENT PRACTICES IN NO-TILL CROPS. Vince M. Davis, Greg R. Kruger, Andrew M. Westhoven, and William G. Johnson, Research Associate, Graduate Research Assistant, Graduate Research Assistant, and Associate Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Horseweed, *Conyza canadensis*, is an increasingly common and problematic weed in no-till soybean production in the eastern cornbelt due to the frequent occurrence of biotypes resistant to glyphosate. The objective of this study was to determine the influence of crop rotation, winter wheat cover crops (WWCC), residual non-glyphosate herbicides, and burndown application timing on the population dynamics of glyphosate resistant (GR) horseweed. A field study was conducted from 2003 to 2005 in a no-till field located in southeastern Indiana where glyphosate-resistant biotypes are a common occurrence in no-till fields. The experiment was a split-plot design with crop rotation (soybean-corn or soybean-soybean) as main plots and management systems as subplots. Management systems were evaluated by quantifying in-field horseweed plant density, and seedbank density. Crop rotation did not influence in-field horseweed or seedbank densities at any data census timing. Burndown herbicides applied in the spring were more effective at reducing horseweed plant densities than when applied in the previous fall. Horseweed seedbank densities declined rapidly in the soil by an average of 76% for all systems over the first ten months prior to new seedrain. Despite rapid decline in total seedbank density, seed for GR biotypes remained in the seedbank for at least two years. Therefore, to reduce the presence of GR horseweed biotypes in a local no-till weed flora, integrated weed management (IWM) systems should be developed to reduce both GR and GS horseweed biotypes.

INFLUENCE OF HENBIT AND PURPLE DEADNETTLE DENSITY ON PLANT BIOMASS AND SOYBEAN CYST NEMATODE REPRODUCTION. Valerie A. Mock*, J. Earl Creech, and William G. Johnson, Graduate Research Assistant, Graduate Research Assistant, and Associate Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907-2054.

Winter annual weeds such as henbit and purple deadnettle have been an increasing problem as no-till systems are becoming more common and use of residual herbicides declines. These two weeds are also known to serve as alternate hosts for soybean cyst nematode (SCN) and could result in population increase if not controlled. A greenhouse study was conducted to determine how densities of henbit and purple deadnettle affect SCN reproduction. This experiment was a two-factor factorial which had 10 plant density combinations and two SCN inoculation levels (0 or 10,000/pot). Plants were grown at a 14 hour photoperiod at 24 ± 5 C. Two weeks after planting pots that were to receive SCN eggs were inoculated with 10,000 eggs. Six weeks after pots were inoculated stem counts were taken, and plant foliage was harvested for dry weight. Roots were harvested for SCN cyst and egg counts as well as dry weights. Shoot and root dry weight of soybean, henbit, and purple deadnettle were not affected by SCN. Shoot and root biomass per pot of purple deadnettle and henbit were similar at the same densities and generally increased and density increased. Henbit produced more stems than purple deadnettle, but stem number decreased as plant density per pot increased. The highest SCN densities were observed in pots with low to moderate densities of purple deadnettle and moderate to high densities of henbit.

TIME OF TILLAGE EFFECTS ON WEED COMMUNITIES IN CONTINUOUS SOYBEANS. John Cardina and Catherine P. Herms, Associate Professor and Research Associate, Department of Horticulture and Crop Science, The Ohio State University / Ohio Agricultural Research and Development Center, Wooster, OH 44691.

A weed seedling emergence study was conducted from fall 1996 through fall 2001 to evaluate the long-term impacts of the use and timing of tillage on weed communities in a continuous soybean system. The study was conducted in a 1-ha field at the Ohio Agricultural Research and Development Center near Wooster, Ohio. The field had been in a corn-soybean rotation for three years prior to initiating the study. A 2 x 2 x 2 factorial experiment was conducted in a randomized complete block design with five replications. The three factors were fall field preparation (tillage / no tillage), spring field preparation (tillage / burndown) and the timing of spring preparation (early / late). Tillage consisted of a single pass with a chisel plow, followed immediately by a disking/finishing tool. Fall tillage occurred about two weeks after the first killing frost. Early spring tillage occurred at the earliest practical time the soil was fit for equipment operation, and late spring tillage occurred at the latest practical time for soybean planting. For burndown treatments, glyphosate herbicide was applied up to eight days before planting. Following early and late spring treatments, a glyphosate-tolerant soybean variety was planted at 18-cm row spacing in plots 6.1 m wide and 15.2 m long. Weed seedling emergence was counted immediately before spring field operations and weekly thereafter through the growing season in eight permanent quadrats (30 x 30 cm) per plot. The seasonal total and relative abundance index (RAI = relative density + relative frequency / 2, where relative density = number of weed Y / total number of weeds, relative frequency = absolute frequency of weed Y / total absolute frequency of all weeds, and absolute frequency = number of samples with weed Y / total number of samples) of each weed species was calculated, and data were analyzed using multivariate techniques in PC-ORD (version 4, MJM Software Design). Indicator species analysis was performed using abundance data, and MRBP (blocked multi-response permutation procedures) and cluster analysis were performed using RAI data. Only results from the final year of the study (2001) are reported here.

Twenty nine weed species were recorded in field emergence counts in 2001. Plots clustered into two main groups based upon the timing of spring field preparation. Weed communities in early spring tillage and burndown plots were more similar to each other than to weed communities in late spring tillage and burndown plots, and vice versa. The MRBP analyses confirmed this result, but also indicated an effect of the interaction of the timing and type of spring field preparation on weed community composition. Based upon indicator species analysis, mouseear chickweed (*Cerastium vulgatum* L. CERVU) and wild carrot (*Daucus carota* L. DAUCA) were associated with early spring tillage plots, velvetleaf (*Abutilon theophrasti* Medicus ABUTH) was associated with early burndown plots, common chickweed (*Stellaria media* L. Vill. STEME), common purslane (*Portulaca oleracea* L. POROL), dandelion (*Taraxacum officinale* Weber in Wiggers TAROF) and purple deadnettle (*Lamium purpureum* L. LAMPU) were associated with late spring tillage plots, and field pennycress (*Thlaspi arvense* L. THLAR) was associated with late burndown plots. There was no effect of fall field preparation on weed communities. In summary, both the timing and type of field preparation in the spring had an impact on weed community composition in a continuous soybean system.

LUMAX (*S*-METOLACHLOR & ATRAZINE & MESOTRIONE) PERFORMANCE IN GRAIN SORGHUM. David L. Regehr, Gary L. Cramer, Curtis R. Thompson, Phillip W. Stahlman, and Patrick W. Geier, Professor, Sedgwick County Extension Agriculture Agent, and Professor, Kansas State University, Manhattan 66506, and Professor and Assistant Scientist, Agricultural Research Center, Hays 67601.

In 2006, a Section 18 Emergency Exemption allowed the use of Lumax herbicide on grain sorghum in Kansas, to control triazine- and/or ALS-resistant broadleaf weeds. Field experiments were established in Sedgwick and Stevens Counties, and at Hays, to compare soil-applied Lumax treatments to standard soil-applied s-metolachlor plus atrazine products and to foliar-applied alternatives that, depending on location, included prosulfuron, dicamba plus atrazine, fluroxypyr, carfentrazone-ethyl, bromoxynil, and 2,4-D. All locations received adequate precipitation to activate the soil-applied herbicides.

At Colwich in Sedgwick County, Lumax, s-metolachlor plus atrazine, atrazine, and s-metolachlor were applied three days after planting, just as an extremely heavy population of Palmer amaranth was about to emerge. Lumax provided significantly better pigweed control than any other treatment, but even this treatment had five to ten pigweeds per plot that escaped control, and sorghum yield was reduced 34% compared to the weed-free check. However, this was much less yield loss than the 87, 86, and 61% loss suffered by atrazine, s-metolachlor, and s-metolachlor plus atrazine, respectively.

At Clearwater in Sedgwick County, Lumax was the only treatment to provide satisfactory, season-long control of Palmer amaranth that appeared to be both triazine- and ALS-resistant.

In Stevens County, kochia, Russian thistle, and Palmer amaranth populations appeared not to be triazine- or ALS-resistant. Soil-applied s-metolachlor plus atrazine, and atrazine followed by foliar-applied prosulfuron, provided excellent control of weeds. This control significantly surpassed that of Lumax in some instances. At this location, some plots suffered from kochia that flourished following inadequate control by the preplant burndown treatment.

At Hays, weed infestations were light. Preplant Lumax gave better control of prostrate spurge, tumble pigweed, and puncturevine, than did s-metolachlor plus atrazine. Among foliar-applied treatments, fluroxypyr plus atrazine and carfentrazone-ethyl plus atrazine generally out-performed dicamba plus atrazine, and carfentrazone-ethyl plus 2,4-D.

GRAIN SORGHUM RESPONSE TO SOIL APPLIED MESOTRIONE. John C. Frihauf, Phillip W. Stahlman, David L. Regehr, Mark M. Claassen, Larry D. Maddux, Curtis R. Thompson, Alan J. Schelegel, and James M. Lee, Graduate Research Assistant, Professor, Professor, Professor, Professor, Professor, Professor, and Assistant Scientist, respectively, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Field experiments were conducted at six sites in Kansas during the 2003, 2004, and 2005 grain sorghum growing seasons (12 site-year environments) to evaluate the response of grain sorghum to premixtures of mesotrione & *S*-metolachlor & atrazine, mesotrione & *S*-metolachlor, and *S*-metolachlor & atrazine applied at different rates and timings. These herbicides were applied early preplant (EPP, 16 to 25 days preplant), late preplant (LPP, 7 to 14 days preplant), and preemergence (PRE, 0 to 3 days after planting) at one (1X) and two (2X) times recommended field use rates for corn or sorghum. Analysis of data with sites and years as random effects indicated a significant rate by timing interaction for crop injury averaged across 12 environments. Injury was greatest (8%) at the 2X use rate and PRE application timing, averaged across herbicides. In comparison, injury was ≤ 4% for the 2X use rate and EPP or LPP treatment combinations as well as for the 1X use rate, regardless of application timing. Grain sorghum fully recovered from the injury and yield was not impacted by herbicides, rates, or timings. The data were reanalyzed with sites and years as fixed effects to make comparisons among experiments. Little or no injury was observed for any treatment in 4 of 12 experiments, and little or no injury was observed when herbicides were applied EPP or LPP in most other experiments. Effects of herbicide, rate, and application timing on crop injury and yield were inconsistent. Mesotrione & *S*-metolachlor & atrazine and mesotrione & *S*-metolachlor applied PRE at the 2X use rate caused the greatest injury in three experiments, and PRE application at the 2X use rate averaged over herbicides resulted in the greatest injury in three other experiments. Grain sorghum yield was not reduced by any treatment variable in four experiments. In the remaining experiments, yield was affected by the main effects of timing or rate, or a rate by timing interaction. In two experiments, grain sorghum yield, averaged over herbicides and rates, was 5 or 10% and 4 or 11% lower for PRE compared to EPP or LPP application timings, respectively. Herbicide rate significantly influenced yield in three experiments regardless of herbicide applied or timing. Averaged over herbicides and timings, yields were minimally impacted with reductions of 5 to 6% from 2X rates in two experiments and 5% yield reduction was observed from 1X rates in another experiment. There were differing rate by timing interactions for grain yield in two experiments. Averaged over herbicides, yield reductions in one experiment were greater at 1X compared to 2X use rates when herbicides were applied EPP or LPP, while in the other experiment application at 2X use rates and LPP timing reduced sorghum yield the most. Correlation analysis indicated that early-season crop injury was not a good indicator of grain sorghum yield in most experiments. Injury and yield data generally indicate mesotrione & *S*-metolachor & atrazine and mesotrione & *S*-metolachlor are just as safe as *S*-metolachlor & atrazine when applied at LPP or EPP timing to grain sorghum.

FARM-LEVEL PROFITABILITY OF WEED AND INSECT MANAGEMENT STRATEGIES IN TRANSGENIC AND NONTRANSGENIC CORN. Kathrin Schirmacher, Scott M. Swinton, James J. Kells, and Christina D. DiFonzo, Graduate Student, Department of Crop and Soil Sciences, Professor, Department of Agricultural Economics, Professor, Department of Crop and Soil Sciences, and Associate Professor, Department of Entomology, Michigan State University, East Lansing, MI 48824-1325.

Stacking of traits has led to corn hybrids that contain resistance for both herbicides and insects. Stacked trait corn hybrids are currently being aggressively marketed to corn producers. Transgenic traits offer corn growers new options for weed and insect management. These options are often more environmentally friendly and carry less risk to users than conventional strategies. Adoption of this new technology will occur only if there is a clear economic advantage over current practices. This 3-year study examines the management of weeds and corn rootworm via stacked transgenic corn hybrids compared to conventional insect and weeds management strategies. Profitability of this technology is a function of the efficacy and consistency of pest management and resulting crop yield preservation. The economic value of these traits has not been determined under Michigan conditions. The profitability of resistance traits in corn hybrids for Michigan corn producers varies according to the levels of pest infestations. This research identifies the level of pest infestations in which the cost of these stacked transgenic traits are justified in relation to conventional practices.

COMPARING MESOTRIONE, TEMBOTRIONE, AND TOPRAMEZONE. Rich Zollinger and Jerry L. Ries, Professor and Research Specialist, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105-5051.

Replicated field research was conducted in 2006 to evaluate efficacy of mesotrione, tembotrione, and topramezone applied at 1X and 0.75X rates and with basic pH blend, MSO-type, and basic pH blend plus MSO-type adjuvants. No herbicide treatments caused visual corn injury. All treatments completely controlled redroot pigweed, common lambsquarters, wild mustard, kochia, hairy nightshade, and common cocklebur through the growing season. The weeds that were not completely controlled were yellow foxtail, wild buckwheat, and common ragweed. The following summary statements are from the 28 day after application evaluation. Adjuvant enhancement of all three herbicides were MSO>basic pH blend=MSO + basic pH blend. Wild buckwheat control was less than 40% with all three herbicides. However, adding 0.38 lb/A of atrazine to all three herbicides gave complete control. Mesotrione gave less yellow foxtail control (65%) than tembotrione and topramezone (88 and 92%). Mesotrione gave less common ragweed control (52%) than tembotrione and topramezone (94 and 97%). Tembotrione gave approximately 10% points greater yellow foxtail control at 1X than at 0.75X (89, 80%) but there was no difference in control with topramezone at either rate (92, 91%). In another study mesotrione, tembotrione, and topramezone were each applied at the 1X rate with MSO adjuvant with atrazine at 0.38 lb/A, or foramsulfuron + safener at 0.53 oz/A, or a deposition + drift retardant adjuvant (In-Place) at 0.75 fl oz/A. Foramsulfuron applied with mesotrione improved yellow foxtail control from 57 to 90% and control was greater than with atrazine or In-Place. In-Place enhanced the activity of tembotrione or topramezone on yellow foxtail from 89 to 97% and control was greater than the other components. All three additives applied with mesotrione increased common ragweed control from 57 to 95%. Common ragweed control from tembotrione or topramezone applied alone was 95%. Adding any of the other three additives to topramezone slightly increased control.

INTERACTION OF HERBICIDES AND ADJUVANTS WITH AE 0172747 ON POSTEMERGENCE GRASS CONTROL. Mark A. Waddington and Bryan G. Young, Graduate Research Assistant and Associate Professor, Southern Illinois University, Carbondale, IL 62901.

The experimental product AE 0172747 is an HPPD-inhibiting herbicide being developed for postemergence grass and broadleaf control in corn. Two field studies were conducted in 2006 at the Southern Illinois University research farms in Belleville and Carbondale to evaluate the efficacy of AE 0172747 applied alone on grass species and in several tank-mixtures of herbicides and adjuvants to determine their influence on grass control.

Control of giant foxtail and broadleaf signalgrass was at least 87 and 91%, respectively, for AE 0172747 applied alone with either crop oil concentrate (COC) or methylated seed oil (MSO). The use of COC, MSO, nicosulfuron, foramsulfuron, or atrazine with AE 0172747 had only a slight impact on control of giant foxtail and broadleaf signalgrass. Conversely, control of fall panicum with AE 0172747 applied alone was less than 8% regardless of adjuvant. Control of fall panicum was 45 to 89% from combinations of foramsulfuron plus AE 0172747 and control generally increased as the rate of foramsulfuron increased. Control of fall panicum was 72 to 96% from combinations of nicosulfuron plus AE 0172747. However, increasing the rate of nicosulfuron beyond 75% of the normal use rate did not usually increase control of fall panicum. In most instances, fall panicum control was greater when MSO was utilized with either foramsulfuron or nicosulfuron tank-mixed with AE 0172747 compared with COC. When the sulfonylurea grass herbicides were applied with AE 0172747 the addition of atrazine provided variable results for control of fall panicum.

INFLUENCE OF RESIDUAL HERBICIDE RATE AND TIMING ON WEED MANAGEMENT IN GLYPHOSATE-RESISTANT CORN. Daniel D. Schnitker, Bryan G. Young, William G. Johnson, and Mark M. Loux, Graduate Research Assistant and Associate Professor, Southern Illinois University, Carbondale, IL 62901, Associate Professor, Purdue University, West Lafayette, IN 47907, Professor, The Ohio State University, Columbus, OH 43210.

The adoption of glyphosate-resistant corn continues to increase as producers search for alternatives to traditional herbicide programs. The commercial use of glyphosate-resistant corn has resulted in less interest and use in residual herbicides applied prior to or at planting. Field research was conducted in Illinois, Indiana, and Ohio in 2006 to evaluate residual herbicide factors preceding a planned in-crop glyphosate application. The objectives of this research were 1) to determine the effect of residual herbicide rates and timings (14 days early-preplant and at planting) and 2) to evaluate postemergence glyphosate timings (early POST and late POST) on weed control and grain yield. Residual herbicide treatments included atrazine, atrazine plus simazine, atrazine plus isoxaflutole, acetochlor plus atrazine and atrazine plus *s*-metolachlor plus mesotrione.

Crop injury was not observed for any herbicide treatment. Control of giant foxtail, giant ragweed, and velvetleaf at the POST timing was up to 14% greater with a residual herbicide applied at planting than applied 14 days before planting. No significant differences were observed with the timing of the residual herbicides for control of common lambsquarters and redroot pigweed. Control of giant foxtail, giant ragweed, velvetleaf, and common lambsquarters from the residual herbicides at the early POST timing was up to 13% greater than the late POST application timing. Atrazine applied at 1.12 and 2.24 kg ai/ha or atrazine (1.12 kg ai/ha) plus simazine (1.12 kg ai/ha) provided less residual control of all broadleaf and grass species than the premix of acetochlor plus atrazine at the full labeled rate. Atrazine plus *s*-metolochlor plus mesotrione at a two-thirds and full labeled rate provided greater than 95% control of giant foxtail, velvetleaf, and common lambsquarters with greater than 80% control of giant ragweed. Atrazine applied at 1.12 to 2.24 kg ai/ha provided the least control of all broadleaf and grass species. Significant yield reductions, due to weed competition before the planned POST application of glyphosate at the V6 stage of corn growth, resulted from the application of the residual herbicides 14 days prior to planting rather than at planting. The timing of the POST glyphosate application had no significant effect on grain yield if a residual herbicide was applied at planting. Reliance on a single POST application of glyphosate resulted in up to 25% yield losses. This research suggests that the application at planting of a broad spectrum residual herbicide at near full labeled rates is necessary for optimal yields in glyphosate-resistant corn.

BENEFITS OF TRIAZINE HERBICIDES IN REDUCING EROSION AND FUEL USE IN U.S. CORN PRODUCTION. Richard S. Fawcett, President, Fawcett Consulting, Huxley, IA 50124.

Introduction

Soil erosion is one of the greatest threats facing the sustainability of American agriculture. Erosion caused by water and wind reduces present and future crop yields and produces adverse off-site impacts, such as sedimentation of lakes and streams, and transport of nutrients and pesticides to surface waters.

Great strides have been made to reduce erosion and its adverse impacts. Most of this progress had been made due to adoption of conservation tillage systems by farmers. Conservation tillage systems involve reduction or elimination of preplanting tillage in order to leave part or all of the crop residues (leaves and stems) from the previous crop on the soil surface. Conservation Compliance provisions of the 1985 Farm Bill required that farmers participating in any government farm program comply with Conservation Plans designed to reduce erosion on highly erodible land (HEL) to sustainable levels. Over 75% of Conservation Plans used some form of conservation tillage

The 2001 National Resources Inventory (Natural Resources Conservation Service 2003) showed that dramatic decreases in erosion have taken place in the United States since 1982, much of it due to adoption of conservation tillage. Sheet and rill (water) erosion fell from an average 4.0 tons/acre/yr in 1982 to 2.7 tons/acre/yr in 2001, a 33% drop. The average wind erosion rate also dropped 36% during the same period of time. Herbicides, especially the triazine herbicides, have been essential components of conservation tillage, substituting for intensive tillage. No-till systems eliminate all tillage other than that performed by the planter. Mulch tillage systems (often called reduced tillage) eliminate use of the moldboard plow of conventional tillage systems and reduce other tillage to leave part of the previous year's crop residue on the soil surface. In order for tillage systems to be classified as conservation tillage, at least 30% of the soil surface must be covered with crop residue following planting.

Triazine Herbicides and Conservation Tillage

Atrazine and simazine are especially valuable in conservation tillage systems in corn because they provide excellent residual control, and are not tightly adsorbed to surface crop residue, but wash easily from residue to the soil. Atrazine also provides postemergence activity, helping to control emerged weeds. Low vapor pressures also avoid excessive vapor losses of residue-intercepted herbicide. The importance of atrazine to conservation tillage farmers is illustrated by the preferential use of atrazine in conservation tillage. Atrazine was used on 61.7% of conventional tillage corn in 2004 and 84.1% of conservation tillage corn. If atrazine and simazine herbicides were not available, farmers could be expected to increase tillage to control weeds in the absence of effective herbicides.

Soil Erosion Reduction with Conservation Tillage

Reductions in erosion from conservation tillage are due to the protective effects of surface crop residue. Greater levels of residue reduce erosion more (Table 1). Erosion rates following different tillage systems can be predicted from studies which measure how much surface residue remains following tillage. As corn and soybean crops produce differing amounts of crop residue of differing persistence, erosion rates are affected by the preceding crop. Each tillage operation buries additional crop residue. Table 2 shows expected residue cover following various tillage programs and erosion rates that would result, expressed as a percentage of erosion occurring with conventional tillage.

The Conservation Technology Information Center (CTIC) conducts a survey of tillage practices on U.S. cropland every two years. Total acres under conservation tillage, as well as acres in no-till, and acres in mulch tillage are recorded. Mulch tillage can use many different combinations and types of tillage tools, but must leave at least 30% of the soil surface covered with residue. Mulch tillage fields may have anywhere from 30% to as much as 50% or more of the soil surface covered with residue, but

Table 1. Soil erosion as a percent of erosion expected with a moldboard plow system for various residue covers given a percent of the land surface covered by crop residue.

Residue cover[a] (%)	Erosion[b] (%)
10	70
20	43
30	26
40	16
50	10
75	3
100	1

[a]Residue cover is the percent of the land surface covered by crop residue.
[b]Erosion is the percent of that expected if moldboard plowed. (From Laflen, J.M., W.C. Moldenhauer, T.S. Colvin, and W.F. Buchele. 1982. Erosion control. In: Farm agricultural resource management conference on conservation tillage, Iowa State University.)

less residue cover than no-till fields. Fields with 30% residue cover have erosion rates 26% of those under conventional tillage (Table 1). Some mulch tillage fields would have residue coverage of 40 or 50%, with erosion rates of 16% or 10% of conventional. At a minimum, mulch tillage fields would reduce erosion to 26% of conventional. No-till fields usually have about 80% residue cover, reducing erosion to about 3% of conventional (Tables 1 and 2).

Table 2. Expected residue cover and soil erosion for combinations of tillage tools and planters.

Tools[a]	Following corn or meadow		Following soybeans	
	% cover[b]	% soil erosion[c]	% cover[b]	% soil erosion[c]
P (No Till)	81	3	81	3
CP, D, P	31	25	14	57
CP, D, D, P	22	39	7	82
D, D, FC, P	34	19	12	65
D, D, P	40	16	20	43
D, FC, P	48	11	24	36
D, P	57	7	40	15
FC, P	69	4	48	11

[a]The order of operations does not affect the estimates of residue cover or soil erosion.

Abbreviations: P - Plant
CP - Chisel Plow
D - Disc
FC - Field Cultivator

[b] % Cover is percent of the land surface covered by crop residue.
[c] % Soil erosion is the percent of that expected if moldboard plowing had been used instead of the combination of tools given. (Adapted from Laflen, J.M., W.C. Moldenhauer, T.S. Colvin, and W.F. Buchele. 1982. Erosion control In: Farm agricultural resource management conference on conservation tillage, Iowa State University.)

If farms were to switch from mulch tillage to conventional tillage erosion would be 100% of conventional instead of 26%, an increase of 285% ([100%-26%]÷26%). Farms switching from no-till to conventional would have 100% erosion rather than 3% erosion rate, increasing erosion by 3233% ([100%-3%]÷3%). Farms switching from no-till to mulch tillage would have 26% erosion instead of 3%, increasing the erosion rate by 767% ([26%-3%]÷3%).

Fuel Savings with Conservation Tillage

Conservation tillage systems also save fuel due to fewer tillage trips (Table 3). A conventional tillage system consumes about 5.3 gal fuel/acre; a mulch tillage system uses about 3.3 gal/acre; and no-till uses about 1.4 gal/acre fuel (Ayers 1989; Jasa et al. 1991). Conversion from conventional tillage to no-till for row crops would save the equivalent of 3.9 gal/acre of diesel fuel, a reduction of 74%. Switching from conventional tillage to a mulch tillage system would save about 2 gal fuel/acre, a 38% reduction. If fields were converted from conservation tillage back to more tillage intensive systems, fuel use would rise dramatically.

Table 3. Estimated annual increase in soil erosion and fuel use under several tillage change scenarios accompanying loss of the availability of triazine herbicides.

Tillage Conversion Scenarios	Increase Estimated with Reductions in Conservation Tillage	
	Soil Erosion (tons/year)	Fuel Usage (gallons/year)
All No-till to Conventional	153 million	62 million
½ No-Till to Conventional	77 million	31 million
All No-Till to Mulch Till	36 million	30 million
½ No-Till to Mulch Till	18 million	15 million
All Mulch Till to Conventional	99 million	27 million
½ Mulch Till to Conventional	50 million	13 million
All No-Till & Mulch to Conventional	252 million	89 million

Moisture Conservation with Conservation Tillage

Besides saving soil and fuel, conservation tillage systems conserve soil moisture by reducing evaporation caused by tillage. Moisture conservation is especially important in the semi-arid areas of the western U.S. where grain crops can be grown only by storing soil moisture for all or part of a growing season or "fallowing" land. During the time crops are not present, weeds must be controlled to prevent reductions in soil moisture. Traditionally, weed control was done by repeated tillage operations. During the 15 to 19 month fallow period, 5 to 7 tillage passes were made (Regehr and Norwood, In Press). However, tillage increased wind erosion prevalent in these areas, caused evaporation losses of water, and used costly fuel. Ecofallow or chemical fallow systems use herbicides such as atrazine to control weeds in absence of tillage. Atrazine can be used during the fallow period in wheat-sorghum-fallow, wheat-corn-fallow, and wheat-fallow-wheat rotations. Atrazine's low cost and broad spectrum weed control have made these fallow rotations profitable in areas where grain production would otherwise not be economically feasible.

Greater water storage allows shortening of the fallow period, meaning grain crops could be grown more often than in the past. This greater water storage with chemical fallow, compared to conventional tillage fallow, has increased profitability and reduced risk of grain production in the Great Plains of the United States (Norwood 1994). Regehr and Norwood (In Press) have reviewed the importance of atrazine to ecofallow and concluded, "At present, no other herbicide approaches the economic and biological advantages of atrazine." Indeed, Extension Weed Specialists report that nearly all the estimated 1 million ecofallow acres in rotations with corn or sorghum and wheat in Kansas, Nebraska, and Colorado are currently treated with atrazine (personal communication Dave Regehr, Kansas State Univ.; Bob Wilson, Univ. of Nebraska; Bob Klein, Univ. of Nebraska).

Increases in Erosion and Fuel Use if Conservation Tillage Decreases

In order to estimate the effect of increased tillage in fields now under conservation tillage on erosion losses across all U.S. corn, average erosion potential with no surface residue must be estimated for these soils. Because conservation tillage is more often practiced on highly erodible land (it is these HEL fields which must have Conservation Plans), fields now under conservation tillage are more vulnerable to erosion than most current conventional tillage fields, should tillage increase. In 1982, the National Resources Inventory indicated a national average total erosion rate on all cropland of 8 tons/acre (Natural Resources Conservation Service, 2001). By 1982 many farmers had reduced tillage so that 70% of all U.S. cropland was no longer moldboard plowed (Fawcett 1987). Much of this land received repeated tillage, resulting in less than 30% crop residue cover, but erosion would still be reduced compared to plowing. Thus, true erosion potential of cropland would be considerably greater than 8 tons/acre. Considering that land now under conservation tillage is inherently more vulnerable to erosion, 10 tons/acre is a conservative estimate of potential erosion on such land should it return to conventional tillage.

Using a 10 ton/acre average erosion rate potential for land now under conservation tillage, the average erosion rate for conventional tillage, mulch tillage and no-till on such land would be 10 tons/acre, 2.6 tons/acre, and 0.3 tons/acre. (100% x 10 tons; 26% x 10 tons; and 3% x 10 tons). Thus, farms switching from no-till to conventional tillage would increase erosion by 9.7 tons/acre. Farms switching from mulch tillage to conventional would increase erosion by 7.4 tons/acre. Farms switching from no-till to mulch tillage would increase erosion by 2.3 tons/acre.

In 2004, there were 15,817,795 acres of no-till corn and 13,438,132 acres of mulch tillage corn in the U.S. (Conservation Technology Information Center 2004). Table 3 contains estimates of the increases in annual soil erosion and fuel use in the U.S. under several tillage change scenarios which could occur if farmers lost important conservation tillage tools, such as the triazine herbicides. If farmers had to again rely more on tillage for weed control, these possible changes could occur: no-till farmers might switch either to mulch tillage or to conventional tillage; mulch tillage farmers might switch to conventional tillage. If all farmers reverted to conventional tillage, all soil erosion benefits and fuel conservation would be lost, with an estimated annual increase in soil erosion of 252 million tons and estimated annual increase in fuel use of 88.6 million gallons. Even a modest change scenario of ½ no-till acres converting to mulch tillage and ½ of mulch tillage acres converting to conventional tillage would result in an estimated annual increase in erosion of 68 million tons and increased fuel use of 28.4 million gallons.

Literature Cited

Ayers, G.E. 1989. Fuel required for field operations. Extension publication PM-709. Iowa State University, Ames, IA.

Conservation Technology Information Center. 2004. National crop management survey. www.ctic.purdue.edu/CTIC/CTIC.html.

Fawcett, R.S. 1987. Overview of pest management for conservation tillage systems. In Effects of Conservation Tillage on Groundwater Quality, T.J. Logan, J.M. Davidson, J.L. Baker, and M.R. Overcash, eds. Lewis Publishers, Chelsea, MI.

Jasa, P.A., D. Shelton, A. Jones and E. Dickey. 1991. Conservation Tillage and Planting Systems. Cooperative Extension Service, University of Nebraska - Lincoln, Lincoln, NE.

Laflen, J.M., W.C. Moldenhauer, T.S. Colvin, and W.F. Buchele. 1982. Erosion control. In: Farm agricultural resource management conference on conservation tillage. Iowa State University, Ames, IA.

Natural Resources Conservation Service. 2001. Summary Report 1997 National Resources Inventory. U.S. Department of Agriculture, Washington, D.C. December 1999, revised December 2000, 90 p.

Natural Resources Conservation Service. 2003. Natural Resource Inventory 2001 Annual NRI. Soil Erosion. U.S. Department of Agriculture, Washington, D.C. July 2003, 4 p.

Norwood, C. 1994. Profile water distribution and grain yield as affected by cropping system and tillage. Agron. J. 86:558-563.

Regehr, David L. and Charles A. Norwood. In Press. Benefits of triazine herbicides in ecofallow. In: The Triazine Herbicides. Homer LeBaron, ed. Elsevier Science.

INFLUENCE OF FALL AND EARLY SPRING HERBICIDE APPLICATIONS ON SOIL CONDITIONS AND INSECT INJURY IN NO-TILL CORN. Nicholas H. Monnig, Travis R. Legleiter, and Kevin W. Bradley, Graduate Research Assistant, Graduate Research Assistant, and Assistant Professor, Division of Plant Sciences, University of Missouri, Columbia, MO 65211.

Field studies were established at two Missouri locations in 2004 and 2005 to evaluate the effects of fall and early spring herbicide applications on soil temperature, soil moisture content, and insect injury in no-till corn production systems. Both experiments received applications of simazine plus 2,4-D, rimsulfuron plus thifensulfuron plus 2,4-D, and glyphosate plus 2,4-D in the fall, 45 days prior to planting (45 days EPP), 30 days prior to planting (30 days EPP), and seven days prior to planting (7 days EPP). During a period from April 1 to April 14, simazine plus 2,4-D applied 45 days EPP did result in higher soil temperatures at a 5 cm depth compared to the untreated control. However, there were few differences in soil temperature present from April 15 to May 1. Soil moisture readings taken during this same time period corresponded with soil temperature readings. Measurements of soil moisture taken at one and three weeks after planting revealed significantly lower soil moisture readings in the untreated compared to herbicide treated plots. The lower soil moisture content of untreated plots possibly allowed them to warm up more rapidly, thereby eliminating any negative impacts that dense stands of winter annual weeds may have had on soil temperature. Evaluations of corn flea beetle (*Chaetocnema pulicaria* Melsheimer) and lepidopteran injury taken at the V2, V4, and V6 corn leaf stages revealed significant differences in injury as a result of these treatments. When dense stands of winter and summer annual weeds were left uncontrolled, corn flea beetle injury was significantly lower than in plots treated with a herbicide. However, when a postemergence herbicide application was made to remove all weed species prior to the V6 sampling date, differences in corn flea beetle injury between the untreated and herbicide treated plots were eliminated. Additionally, removal of all weed species led to higher lepidopteran injury in the untreated.

WEED CONTROL PROGRAMS WITH TEMBOTRIONE IN CORN. David Lamore*, George Simkins, Kevin Watteyne, and Jayla Allen, Bayer CropScience, Research Triangle Park, NC.

Research was conducted at 38 locations in 17 states across the Eastern and Midwestern United States to determine an effective weed management system using tembotrione applied post emergence in field corn. Three systems were studied including reduce rates and combinations of preemergence herbicides (atrazine, isoxaflutole, flufenacet and s-metolachlor) were followed by an early postemergence application of tembotrione (92 g ai/ha), tembotrione + atrazine (92 g ai/ha + 560-1120 g ai/ha) tank mixed with crop oil concentrate or MSO at 1% v/v and 28% UAN at 3.5 l/ha. Rates of the preemergence products varied by region and soil type. Also evaluated were tank mixes of tembotrione (31 g ai/ha) with glufosinate (450 g ai/ha) on glufosinate resistant corn and tank mixes with glyphosate on glyphosate tolerant corn. Comparisons were made between tank mixes of glufosinate and glyphosate with tembotrione, tembotrione with atrazine (560-1120 g ai/ha) and the combination with both tembotrione and atrazine in each herbicide tolerant system.

Crop injury and weed control data were collected approximately 7, 14, 28 and 56 data after the post emergence treatments. No significant crop injury was reported from any location.

Program included tembotrione provide > 90% control of giant foxtail, barnyardgrass, woolly cupgrass, broadleaf signalgrass, common ragweed, common lambsquarters, giant ragweed, redroot pigweed, velvetleaf, tall waterhemp and common waterhemp.

The weed control spectrum offered by tembotrione brings many options for enhanced weed control, weed resistance management, and application timing to the grower. Tembotrione fits conventional and herbicide tolerant crops.

EFFECT OF ATRAZINE AND ADJUVANTS ON WEED CONTROL WITH TEMBOTRIONE IN CORN. George Simkins, David Lamore, Dan Miller, and Jayla Allen, Bayer CropScience, Research Triangle Park, NC 27709.

Studies were conducted at 10 locations (Strawberry Point IA, Mason City IA, Tecumseh NE, Indianola IA, Charles City IA, Bryan OH, Junction City KS, Pawnee IL, Easton IL and Le Sueur, MN) to determine the effect of atrazine and adjuvants on the herbicidal activity of postemergence applied tembotrione in field corn. All treatments consisted of tembotrione (92 g ai./ha), 28% nitrogen (3.5 L/HA) with either crop oil concentrate (1% v/v) or methylated seed oil (0.25, 0.5, 0.75, 1.0 or 1.25% v/v) with or without atrazine (560 g ai/ha). Applications were made when the grass weed were 2.5 to 5 cm. tall (early post) or when they were 7.6 to 10 cm. tall (mid post). Crop injury measurements were recorded 7 and 14 days after application, and weed control efficacy was recorded approximately 21 and 40 days after application. Crop injury was only observed at one test site (Junction City, KS). The only treatments in this trial exhibiting significant injury were those applied early postemergence, which consisted of tembotrione tank-mixed with atrazine, and methylated seed oil at rates of 0.75% v/v or greater. Injury symptoms were transient. Tembotrione treatments provided 95 to 100 % control of the broadleaf weeds present (Common lambsquarter, Eastern black nightshade, Smooth pigweed, Redroot pigweed, Common waterhemp, Ladysthumb, Giant ragweed, Palmer amaranth, Common ragweed, Velvetleaf and Venice mallow). Control of broadleaf weeds evaluated in this study with tembotrionme did not require the addition of atrazine. Either crop oil concentrate or methylated seed oil could be used for the additive system for control of broadleaf weeds. Effective control ($\geq$ 95%) of Giant and Yellow foxtail, Barnyardgrass, Woolly cupgrass and Downy brome was obtained with all tembotrione treatments. Control of small (< 5 cm.) Field sandbur or Crabgrass sp. with tembotrione treatments 14 days after application was effective, but long term control (> 30 days) of larger ($\geq$ 7.6 cm.) Field sandbur and Crabgrass sp. was poor. Green foxtail and Fall panicum control was fair to poor depending on additive system or whether atrazine was used in the tank-mix. Generally the methylated seed oil additive system was more effective for the control of grass weeds than crop oil concentrate. Consistent control of grass weeds required the use of 0.75% v/v or more of methylated seed oil. The addition of atrazine to tembotrione treatments results in superior control of grass weeds.

NEW HERBICIDE MIXTURE FOR FOUNDATION WEED CONTROL IN GLYPHOSATE TOLERANT CORN. Bruce E. Maddy*, Marvin E. Schultz, David C. Ruen, and Jeff M. Edwards, Dow AgroSciences, Indianapolis, IN 46268.

GF-1834 is a new soil applied corn herbicide mixture designed to provide early season control of grass and broadleaf weeds in herbicide tolerant corn, enabling optimal timing of the in-crop postemergence application of glyphosate or glufosinate herbicides. GF-1834 suspo-emulsion formulation contains 510 grams per liter active ingredient (4.25 lb ai per gallon), which includes acetochlor, clopyralid monoethanolamine salt, and flumetsulam at 450 + 45.6 + 14.4 grams ai per liter respectively (3.75 + 0.38 + 0.12 lb ai/gal).

Eleven field trials were conducted in 2006 to evaluate herbicidal efficacy and crop tolerance of GF-1834 when applied preemergence in Roundup Ready® corn. Trials were located in central IA, central MO, southern MN, southern WI, central IL, and western IN. Herbicidal efficacy was evaluated four weeks after the V1 stage. Weed control with the normal 1X use rate of GF-1834, 1043 grams ai per hectare (1.75 pints per acre), was compared to approximate 0.5X rates of several reference herbicide treatments. Crop tolerance with GF-1834 was evaluated at V1, one week after V1 and two weeks after V1. Corn plots were not taken to yield.

Herbicidal efficacy results demonstrate that GF-1834 provided control of grass and broadleaf weeds equal to or superior to the reference treatments. Crop tolerance from all treatments, including 1X and 2X use rates, was commercially acceptable.

EPA registration for an improved version of GF-1834 is anticipated in the first quarter of 2007.

®Roundup Ready is a registered trademark of Monsanto Company.

STATUS® (DIFLUFENZOPYR + DICAMBA + ISOXADIFEN-ETHYL): A NEW BROADLEAF HERBICIDE FOR CORN. Dan E. Westberg*, Caren A. Judge, Nicholas T. Fassler, Troy D. Klingaman, and Leo D. Charvat, BASF Corporation, Research Triangle Park, NC 27709.

Status is a new proprietary herbicide premix of diflufenzopyr + dicamba + isoxadifen-ethyl that will be marketed in 2007 for broadleaf weed control in field and seed corn. It will be formulated as a 56% wettable dispersible granule (WDG). Recommended use rates will range from 2.5 to 5 oz product/A with an application window of 4-inch tall corn (V2) to 36-inch tall corn (V10). BASF and University research trials demonstrated excellent corn safety with Status. In these research trials, Status provided excellent control of annual broadleaf weeds and suppression of key perennial broadleaf weeds. Status applied postemergence in a sequential program following dimethenamid-P preemergence or applied in combination with glyphosate postemergence provided complete broad spectrum weed control. No antagonism on weed control was observed with the glyphosate combinations.

OPTIMUM™ GAT™ TRAIT – NEW TECHNOLOGY FOR WEED MANAGEMENT IN ROW CROPS. David W. Saunders, Raymond Forney, Tim Chicoine, Jerry Green, Linda Castle, and Christine Hazel; Product Development Manager, Global Stewardship Manager, Global Product Manager, and Research Associate, DuPont Crop Protection, Newark, DE 19714; Research Coordinator and Trait Champion, Pioneer Hi-Bred International, Johnston, IA 50131.

In Optimum™ GAT™ trait plants, two traits are combined to provide a new approach to tolerance to two classes of herbicides (glyphosate and ALS-inhibitors) with broad efficacy against weeds in North Central states. The glyphosate N-acetyltransferase gene confers tolerance to glyphosate based on its rapid conversion in crops to the non-herbicidal compound N-acetylglyphosate. The gene coding for this enzyme was isolated from a naturally occurring soil bacterium, improved by gene shuffling to be more active on glyphosate, and incorporated into the germplasm of several crop species via standard molecular biology techniques. The enzyme is expressed constitutively, and confers tolerance to extremely high dosages of glyphosate throughout the plant life cycle. The acetolactate synthase gene in the Optimum™ GAT™ trait plants codes for an ALS enzyme with specific modifications in the amino acid sequence that prevent the ALS-inhibitor herbicides from binding. It provides tolerance to all classes of ALS inhibitors. This technology enables the opportunity to bring new ALS-inhibitor herbicides into crops to address a variety of weed management needs, including species that glyphosate is now having difficulty controlling. DuPont will develop solutions based on industry supported integrated management practices, including utilization of the most appropriate herbicides of various modes-of-action possessing inherent or enhanced selectivity to crops, to address glyphosate, ALS, and other herbicide resistant weed populations. These systems, delivered through proprietary blends technologies, will provide greater flexibility and choices to customers for sustainable weed control practices.

WEED MANAGEMENT IN MINT: CHALLENGES IN A MINOR USE CROP. Mary S. Gumz and Stephen C. Weller, Graduate Research Assistant and Professor, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907.

Weed management is a challenge in peppermint and spearmint production due to the few herbicides available, their limited control spectrum, and the necessity of removing weeds to maintain mint oil flavor quality. Our research has focused on the evaluation of new herbicides to control the worst weed problems in mint: *Amaranthus* species, which reduce yield and contaminate essential oil flavor, and white cockle, an emerging weed problem in no-till mint production. The objective of field trials conducted from 2004 to 2006 was to identify herbicides for control of *Amaranthus* species and white cockle in mint and optimum rates and application timings. Results show preemergence applications of clomazone, mesotrione, and flumioxazin have potential for weed control in mint. Clomazone at 840 g a.i. ha $^{-1}$ offers >90% control of both seedling and rosette stage white cockle with little crop injury. Flumioxazin at 108 g a.i. ha $^{-1}$ controls *Amaranthus* species in established meadow mint fields but can cause unacceptable injury in first year plantings. Mesotrione at 105 g a.i. ha $^{-1}$ also controls *Amaranthus* species with little crop injury when applied preemergence. Postemergence mesotrione applications caused unacceptable injury. In all cases, spring applications to dormant mint offered the best weed control and least crop injury. Post harvest herbicide applications caused unacceptable injury. Mint stand health was a significant factor in crop response to herbicide as vigorous mint stands had less injury than stressed stands and fall plowed mint showed less injury than no-till mint fields.

EVALUATION OF PRE-TRANSPLANT HERBICIDES IN PLASTICULTURE STRAWBERRY,
Joe Masabni, Bronwyn Aly, John Masiunas, Assistant Professor, Department of Horticulture, University of Kentucky, Princeton, KY, 42445, Research Associate, Dixon Springs Agriculture Station, University of Illinois, Simpson, IL 62985, and Professor, Department of Horticulture, University of Illinois, Urbana, IL 61801.

The purpose of this study was to identify herbicides that may be registered for use in a strawberry plasticulture production system, because of the phase-out of Methyl bromide. In Fall 2005, field preparation and herbicide application were done 9 days prior to laying the plastic mulch over raised beds. Two varieties, Camarosa and Chandler, were utilized in this study. Seven different herbicide treatments were randomly applied to plots 30 feet long. Plant vigor ratings were taken in the fall, along with plant injury, weed pressure, and number of plants per plot. In Spring of 2006, number of branch crowns and plant diameter were measured for all plots. Harvest data, fruit quality, plant injury/death, and weed ratings were also measured. The two cultivars performed differently in this study in terms of number of peaks in production. For both cultivars, five out of seven herbicides were not significantly different from each other in terms of harvested yields per plot. In terms of their response to herbicides, both cultivars responded similarly. s-Dimethenamid and flumioxazin are not suitable for plasticulture strawberry production. Sulfentrazone, pendimethalin, terbacil, and oxyfluorfen appear to be safe. Terbacil and oxyfluorfen had lower yields, in absolute values, but not statistically significant from the control or the other herbicide treatments. Sulfentrazone and pendimethalin were the best performers for Camarosa cultivar, but were similar to all other treatments for Chandler cultivar. We are encouraged that currently labeled herbicide such as terbacil and oxyfluorfen have a potential use for plasticulture strawberry production, especially as a pre-transplant application. We are also encouraged that non-labeled herbicides, sulfentrazone and pendimethalin, also have potential use in plasticulture strawberry. This study, however, clearly indicated that s-dimethenamid and flumioxazin are not safe when applied as a pre-transplant under plastic application for annual strawberry production.

LONG TERM WEED CONTROL IN ASPARAGUS. Bernard H. Zandstra and Eric J. Ott, Professor and Research Assistant, Michigan State University, East Lansing, MI 48824.

Asparagus is a perennial crop that is maintained in the field for 15-20 years. New plantis reach maximum production in 6-8 yr, and then begin a slow decline. Several factors may contribute to decline of asparagus vigor and yield, including over-harvest, poor nutrition, soil diseases, weed competition, and herbicide injury. Long residual photosystem II inhibitor herbicides have been the primary preemergence herbicides in asparagus, and there is concern that their use may be contributing to the decline of asparagus fields. A herbicide experiment was established to determine whether herbicide treatments reduced yield over a 5-yr period.

Preemergence herbicide treatments were applied on a 10-yr old asparagus field in April, 2000, at the Asparagus Research Farm in Hart, MI. The soil was a fine sandy loam with 84% sand and 1.4% OM. Postemergence treatments were applied to some plots in early June. The same treatments and timing were used in 2000-2005. Asparagus was snapped by hand beginning about May 1, and at least 20 harvests were taken each year, with the final harvest about June 15. Asparagus yield was weighed at each harvest. Weeds were rated visually. Total and average yields were calculated over the life of the experiment.

Preemergence treatments that provided very good control of most annual weeds through the harvest season included diuron 1.34 kg/ha plus metribuzin 0.67 kg/ha, flumioxazin 0.45 kg/ha, sulfentrazone 0.28 kg/ha, and terbacil 1.34 kg/ha. Diuron 1.34 preemergence followed by dicamba 0.56 kg/ha plus sethoxydim 0.21 kg/ha postemergence gave the best control of all annual and perennial weeds. The highest average yield was provided by flumioxazin 0.45 kg/ha preemergence. Other high-yielding treatments were terbacil 1.34 kg/ha preemergence, sulfentrazone 0.28 kg/ha preemergence, halosulfuron 0.053 kg/ha preemergence, and diuron 1.34 kg/ha preemergence followed by dicamba plus sethoxydim postemergence.

Lowest yield over 5 yr was produced by diuron 1.34 plus metribuzin 0.67 kg/ha, and norflurazon 2.24 kg/ha. Diuron plus metribuzin gave good weed control, but consistently lower yield. Yield reduction may have been a response to herbicide treatments. Norflurazon had good weed control early in the season, but many weeds germinated in June. Yield reduction after application of norflurazon probably was a result of weed competition later in the season.

Repeated use of some herbicides may contribute to reduced asparagus yield. Rotating to herbicides of other modes of action may help avoid long-term crop injury.

WEED CONTROL AND TOMATO CULTIVAR SENSITIVITY TO THIFENSULFURON-METHYL. Douglas Doohan and Joel Felix, Associate Professor and Research Associate, Department of Horticulture and Crop Science, The Ohio State University, Ohio Agricultural Research and Development Center (OARDC), Wooster, OH 44691.

Thifensulfuron-methyl is a sulfonylurea herbicide registered for use on wheat, barley, oats, field corn, and soybean with a potential for use on tomato. Applied postemergence on transplanted tomato, thifensulfuron-methyl will control emerged triazine resistant common lambsquaters, common purslane, Pennsylvania smartweed, and red root pigweed. This research was conducted to determine the tolerance of processing tomato varieties currently used in the Midwest and those being developed for future release. Experiments were conducted at the OARDC in Wooster. A split-plot design with four replications was used. Tomato varieties were 'TR-12224469-99', '401401TJ', '611-61103', '46TJ0203', '111-111-2001-02', '9704-5116TCS', '818-818TJ01-03', and '331-BF04T005-04'. A blanket application of *s*-metolachlor (1.33 pt/a) was applied to all plots before tomato transplanting. Thifensulfuron-methyl was applied (0, 8, and 16 oz product/A) postemergence 3 weeks after tomato transplanting. Non-ionic surfactant was included in the spray mix at 0.25% V/V. Tomato plants were evaluated for injury (chlorosis, fullness of the row, and stunting) at 1 and 3 weeks after application. Plants were grown to maturity and yield (tons/A) was determined.

Severe injury was observed starting 3 days after thifensulfuron-methyl application on tomato variety coded 'TR-12224469-99'in 2006. Seven days after application stunting of this variety was 34 and 43%, for 8 and 16 oz/A, respectively. The injury was characterized by yellowing of the sprayed leaves as well as new growth and leaf mottling. Plants quickly grew out of this injury, and evaluations done 6 weeks after treatment indicated only minor yellowing of new leaves on varieties coded 'TR-12224469-99' and '111-111-2001-02'. Higher tomato marketable yield was observed in thifensuluron-methyl treated plots compared to plots treated only with Dual Magnum, and 'TR-12224469-99' was among the high yielding varieties in this study. Results in 2006 varied somewhat from those reported for 2005. Chlorosis was not observed. Stunting was apparent on most varieties in the test and was still highly visible 3 WAT except variety '611-61103'. Although total yield was similar across thifensuluron-methyl treatments, harvest index was slightly reduced in all varieties.

INFLUENCE OF HERBICIDE, PREPLANT TILLAGE, AND COVER CROP ON JACK-O-LANTERN PUMPKIN FARM-GATE REVENUES. Nathan R. Johanning, S. Alan Walters, and Bryan G. Young, Graduate Research Assistant and Associate Professors, Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901.

Conventional tillage systems in jack-o-lantern pumpkin production rely on cultivation to achieve optimal weed control, which leads to increased soil erosion as well as excessive amounts of soil attached to pumpkin fruit at harvest. No-tillage pumpkin production in the Midwest has been increasing over the last decade, but the lack of weed control in this system is still a great challenge to growers. The combination of cover crops integrated into no-tillage planting systems with proper preemergence and postemergence herbicides may provide additional weed control, reduced soil erosion, and cleaner fruit.

In 2003 and 2004, field studies were conducted evaluating tillage practices (tillage vs. no-tillage), cover crop systems (no cover crop, wheat, or winter rye) and preemergence applications of clomazone, ethalfluralin, or halosulfuron, and/or post-emergence applications of halosulfuron for weed control and pumpkin productivity. Wheat and winter rye were killed approximately 1 June with glyphosate and mowed with a rotary mower to a height of 6 cm approximately 3 weeks later. Herbicide treatments were applied to the soil 2 to 3 days after mowing and ‘Aspen’ pumpkin were direct seeded about 20 June each year.

The use of a cover crop reduced the incidence of smooth crabgrass, but not redroot pigweed at pumpkin harvest. In the absence of any herbicide application plots, without a cover crop had 151 smooth crabgrass plants/m^2 compared with 54 and 49 plants/m^2 for winter rye and wheat, respectively. Preemergence applications of halosulfuron alone were more effective for reducing redroot pigweed density than postemergence applications of halosulfuron alone regardless of cover crop system. Furthermore, preemergence or postemergence applications of halosulfuron alone were more effective at reducing redroot pigweed density than preemergence applications of clomazone plus ethalfluralin. The combination of halosulfuron plus clomazone and ethalfluralin reduced redroot pigweed density (5 plants/m^2) to the greatest extent compared with any other herbicide treatment. Pumpkin yields (number and weight/ha) and farm-gate revenues were influenced by only herbicide treatments and not cultivation method or cover crop system. Pumpkin yields were the highest in the treatments that contained clomazone and ethalfluralin applied preemergence in combination with halosulfuron applied preemergence or postemergence. The greatest farm-gate revenues were from the preemergence application of clomazone, ethalfluralin, and halosulfuron and the weed-free control, generating revenues of $4,762 and $5,740/ha, respectively. Overall, tillage and cover crop had relatively little influence on pumpkin yields and farm gate revenues compared with herbicide treatments. The addition of halosulfuron to clomazone and ethalfluralin provided greater broadleaf weed control resulting in greater jack-o-lantern pumpkin yields and farm-gate revenues.

STIMULATED DRIFT INJURY TO OAKS AND HACKBERRY. Jayesh B. Samtani, James E. Appleby, and John B. Masiunas, Graduate Research Assistant, Research Associate Professor, and Associate Professor, Department of Natural Resources and Environmental Sciences, University of Illinois, 1201 W. Gregory Dr., Urbana, IL 61801.

During 2004 and 2005, two-year-old potted red and white oak seedlings, 0.6 m in height, were treated at 1/4, 1/10, and 1/100X of the standard field-use rate of six herbicides: 1) 2,4-D ester (LV 400) (1.5 kg a.i./ha); 2) glyphosate (Roundup Weathermax) (1.1 kg a.i./ha); 3) 2,4-D ester + glyphosate (0.8 + 1 kg a.i./ha, respectively); 4) dicamba (Clarity) (0.7 kg a.i./ha); 5) acetochlor + atrazine (Harness Xtra) (3.5 kg a.i./ha); and 6) s-metolachlor (Dual Magnum) (2.0 kg a.i./ha). The trees were sprayed with the herbicides at three growth stages: (i) swollen bud, (ii) leaves unfolding stage, and (iii) expanded leaves. Oaks treated with water served as controls. A compressed air sprayer with a moving 80015 EVS spray nozzle delivering 187 liter/ha at 207 kPa was used to apply the herbicides. Weekly visual ratings based on overall health of the plant were conducted. We determined photosynthesis rates once each month and measured leaf area at the end of growing season. The greatest herbicide injury occurred when seedlings were treated at the leaf unfolding stage. Injury developed within five days after treatment (DAT) with the growth regulator herbicides 2,4-D and dicamba. The injury consisted of leaf cupping and rolling, leaf curling, and elongation of the leaf tip. A few seedlings treated with 2,4-D had leaf strapping with parallel veination. Oak seedlings treated at the expanded leaf stage had wilted, browning leaves. Injury from 2,4-D and dicamba lasted throughout the growing season. The chloroacetamide herbicides, acetochlor and s-metolachlor, applied at the leaf unfolding stage caused browning of the interveinal tissue which subsequently dropped off, leaving only the veins. These symptoms are similar to “leaf tatters” which we have observed on mature oak trees. Later flushes of growth were normal. Atrazine in other studies did not enhance chloroacetamide injury. Oak seedlings treated with glyphosate at the leaf unfolding stage had leaf yellowing and browning, abnormal leaves, and death of the growing points. Glyphosate treatment at the expand leaf stage caused slow growth, browning of leaves, and leaf wilting. This study provided documentation of injury symptomology caused by drift from common agronomic herbicides and supported our contention that “leaf tatters” could be caused by chloroacetamide drift.

SEASON-LONG WEED CONTROL IN SOLANEOUS CROPS. Eric J. Ott and Bernard H. Zandstra, Research Assistant and Professor, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Fresh market eggplant production has increased by 76% since 1992, fresh market bell pepper, production has nearly tripled since 1980, processing pepper production has nearly tripled since 1992, and the demand for tomatillo has increased steadily over the last several years. Eggplant (*Solanum melongena* L.), bell and banana pepper (*Capsicum annuum* L.), and tomatillo (*Physalis ixocarpa* Brot.) growers have limited herbicide choices for weed management strategies. Field experiments were conducted in 2006 to evaluate new herbicide options for weed control in eggplant, tomatillo, bell and banana pepper production.

Both experiments utilized three replications in a randomized complete block design. Plot dimensions were 6 feet wide by 35 feet long. Crop varieties utilized in these experiments included Ichiban (eggplant), Tomatillo (tomatillo), Camelot (bell pepper), and Inferno (banana pepper). All plants were started by seed in the greenhouse March 31, and then were transplanted May 25 (eggplant and tomatillo), and June 1 (banana and bell pepper). Treatments were applied for the eggplant and tomatillo experiment May 25 [PPI and pretransplant (PRT)], May 26 [posttransplant (POT)], and June 19 (POST). Treatments in the banana and bell pepper experiment were applied June 1 (PPI, PRT, POT), and June 19 (POST). The eggplant and tomatillo experiment was rated on June 19 and June 27, and the banana and bell pepper experiment was rated on June 19, and June 30. Eggplants were harvested five times, tomatillos four times, banana peppers three times, and bell peppers four times for yield. Yields were combined across harvests.

In eggplant and tomatillo, s-metolachlor at 1.3 lbs/acre at all application timings (PPI, PRT, and POT) and sulfentrazone at 0.14 lb/acre applied at the PRT timing, provided 80-100% grass control without crop injury early in the growing season. Flumioxazin, applied PRT at a rate of 0.064 lb/acre, provided 70-80% control of grasses and broadleaves, but injured both eggplant and tomatillo by 50-60% shortly after treatment. S-metolochlor PRT at 1.3 lb/acre followed by a POST application of halosulfuron 0.023 lb/acre plus sethoxydim at 0.19 lb/acre resulted in greater eggplant yield than 1.3 lb/acre s-metolachlor alone. Tomatillo yields were highest in treatments that received 1.3 lb/acre s-metolachlor POT followed by a POST application of halosulfuron at 0.023 lb/acre plus sethoxydim at 0.19 lb/acre, or a PRT treatment of 0.5 lb/acre of clomazone.

In banana and bell peppers, all PPI, PRT, and POT treatments controlled both grasses and broadleaves 70-100% without noticeable crop injury early in the growing season. A PRT application of sulfentrazone at 0.14 lb/acre significantly reduced banana pepper yield compared to treatments that included clomazone at 0.5 lb/acre or clomazone plus ethalfluralin at 0.25 lb/acre and 0.8 lb/acre respectively. Treatments that included clomazone or 1 lb/acre trifluralin protected yield more than treatments that solely relied on 1.3 lb/acre of s-metolachlor. Bell peppers on average had higher yields in treatments that included clomazone than treatments that did not.

EFFICACY AND TOLERANCE OF HPPD-INHIBITING HERBICIDES IN SWEET CORN. Joseph D. Bollman, Chris M. Boerboom, and Roger L. Becker, Graduate Research Assistant, Professor, Department of Agronomy, University of Wisconsin, Madison, WI 53706, and Professor, Department of Agronomy and Genetics, University of Minnesota, St. Paul, MN 55108.

Mesotrione and topramezone are HPPD-inhibiting herbicides that are currently labeled for postemergence (POST) applications in sweet corn. Tembotrione is a new HPPD-inhibiting herbicide being developed for use in sweet corn. Randomized complete block trials were conducted at Arlington, WI and Waseca, MN in 2006 to evaluate efficacy and hybrid tolerance to POST applications of these herbicides. Mesotrione, topramezone, and tembotrione were applied to Legacy sweet corn at 105, 12, and 138 g ai ha^{-1}, respectively with and without 560 g ai ha^{-1} of atrazine. Topramezone and tembotrione treatments were applied with 1 % v/v crop oil concentrate and 3.5 L ha^{-1} of 28% urea ammonium nitrate while mesotrione treatments were applied with 0.25 % v/v nonionic surfactant. All treatments had *s*-metolachlor applied preemergence at 2.1 kg ai ha^{-1} for grass control. These treatments were compared to 6 broadleaf herbicides currently registered on sweet corn in the efficacy trial. A second study was conducted to determine sweet corn hybrid tolerance to these three herbicides. A split-plot design was used where herbicide treatment was the main plot, rate was the sub-plot, and sweet corn hybrid was the sub-sub-plot. Treatments consisted of mesotrione plus atrazine at the rate above along with either 1 % crop oil concentrate or 0.25 % v/v nonionic surfactant, tembotrione with and without atrazine plus 1 % v/v crop oil concentrate and 3.5 L ha^{-1} of 28% urea ammonium nitrate, and topramezone at 12 or 18 g ai ha^{-1} plus 560 g ai ha^{-1} of atrazine, 1 % v/v crop oil concentrate, and 3.5 L ha^{-1} of 28% urea ammonium nitrate. These rates were applied once and twice (double rate) and were compared to a nontreated control. Six hybrids were used with suspected low, moderate, and high levels of sensitivity. The hybrids were Cahill, Dynamo, GH 2042, GH 2547, GH 9597, and Merit. A preemergence herbicide treatment was applied to the entire experiment to prevent early season weed competition.

Mesotrione, topramezone, and tembotrione with or without atrazine controlled greater than 90% of the velvetleaf and common ragweed at 14 days after treatment (DAT) at both sites. All treatments controlled common lambsquarters greater than 90% except for topramezone at Arlington where control was 88%. This was significantly less than the control provided by mesotrione, tembotrione or topramezone plus atrazine. At 35 DAT, all three herbicides with or without atrazine controlled greater than 90% of common lambsquarters and velvetleaf. These herbicides also controlled greater than 90% of common ragweed except for mesotrione at Waseca, which was controlled at 87%. Neither stunting nor chlorosis occurred at the Arlington site. However, slight chlorosis occurred at Waseca with no statistical difference among these three herbicides, with or without atrazine. Stunting from topramezone was 10%, which was significantly greater than all other treatments.

In the tolerance trial, hybrids were rated for chlorosis and stunting. Tembotrione killed the hybrid Merit at both locations. At 7 DAT, mesotrione caused up to 63% chlorosis of Merit at Arlington and 53% chlorosis at Waseca, whereas topramezone caused up to 2 and 9% chlorosis at Arlington and Waseca, respectively. Mesotrione stunted Merit more than topramezone at 14 DAT. On the other five hybrids, chlorosis at 7 DAT ranged from 0 to 10%, 0 to 9%, and 0 to 14% for tembotrione, topramezone, and mesotrione treatments for both rates at Waseca. Chlorosis at 7 DAT at Arlington ranged from 0 to 2%, 0 to 4%, and 0 to 38% for tembotrione, topramezone, and mesotrione treatments for both rates. The least amount of chlorosis occurred in GH 9597 and GH 2547 across all treatments. Excluding Merit, Dynamo was generally the most sensitive hybrid to these herbicides and the chlorosis was primarily caused by the mesotrione treatments.

INTEGRATED WEED MANAGEMENT APPROACHES: USE OF LANDSCAPE FABRIC AS MULCH IN ORGANIC VEGETABLE PRODUCTION. Joel Felix and Doug J. Doohan, Research Associate and Associate Professor, Department of Horticulture and Crop Science, The Ohio State University/Ohio Agricultural Research and Development Center (OARDC), 1680 Madison Ave, Wooster, OH 44691.

Practices that control weeds cost-effectively and build soil organic matter will improve the profitability of organic agriculture and lead to a biologically buffered soil that will require reduced external inputs in the future. The use of woven black landscape fabric could accelerate reduction in weed seedbank and reduce the need for intensive cultivation to control weeds in fields transitioning to organic production. The woven black landscape fabric is uniquely designed to allow water and air to pass through into the soil, yet it is strong enough to last more than five years.

A field study was initiated at OARDC, Wooster, Ohio during summer 2006 to study the impact of woven landscape fabric on weed seedbank if used as groundcover for the initial three years followed by a combination of flaming, mechanical, and vinegar to manage weeds thereafter. The study was laid out in a split-plot design with groundcover duration (bare, 2 years, and 3 years) as main plots and crops (fresh market tomato, cabbage, and jalapeno pepper) as subplots with treatments arranged in a randomized complete block design in an organic transition field. The ground was moldboard plowed and disc cultivated before spreading and incorporating compost at 25 T/ha. The study had four replications and plots measuring 2.1 wide (two rows) x 3.6m. Registered organic insecticides and fungicides were applied to manage insects and diseases as needed. The soil samples taken to characterize the seedbank at the initiation of the study showed 29 weed species varying in population density but uniformly distributed in the field. Weeds with the highest field uniformity value included grasses, common purslane, giant ragweed, common lambsquarters, Virginia copper leaf, Pennsylvania smartweed, eastern black nightshade, Oxalis, henbit, bittercress, Indian tobacco, and daisy fleabane. The average yield for jalapeno pepper and cabbage was 19 and 31 T/ha, respectively, across the ground cover. Tomato yield was affected by ground cover, with bare ground having only 64% of the 54 T/ha harvested in plots covered with landscape fabric. The reduction in yield for bare ground was directly related to heavy leaf diseases earlier in the season. The study will run on the same plots for the next two years.

WEED MANAGEMENT IN ORGANIC PROCESSING VEGETABLES. Jed B. Colquhoun and Richard A. Rittmeyer, Extension Weed Specialist and Research Specialist, Department of Horticulture, University of Wisconsin-Madison, Madison, WI 53706.

The recent expansion of organic foods in major retail markets has stimulated an interest in organic processing vegetables, yet the feasibility of large-scale production is unknown. Weed management is often the most costly input in small-scale organic vegetable production. The objective of this study was to optimize practical weed management strategies in organic snap bean and sweet corn grown for processing. Weed management programs included combinations of stale seedbed, rotary hoeing, conventional row-crop cultivation and hand-weeding compared to a conventional herbicide plus a single row-crop cultivation treatment. In snap bean, weed biomass in the crop row was similar to the conventional program where row-crop cultivation (one or three cultivations) was used with or without pre-emergence rotary hoeing or stale seedbed. Between-row weed control in the organic programs was greatest when snap beans were cultivated two or three times. Snap bean yield and crop value (production value minus weed control cost) were similar to the conventional weed management program where two or three row-crop cultivations were used or where pre-emergence rotary hoeing was followed by one row-crop cultivation. Organic weed management in sweet corn was more challenging in part because of the lack of early-season crop competitiveness with weeds and the longer crop season relative to snap bean. Sweet corn yield and crop value were similar to the conventional weed management program only where three row-crop cultivations were used or where two row-crop cultivations were followed by hand-weeding.

BROADLEAF WEED CONTROL IN TRANSPLANTED CABBAGE. Harlene M Hatterman-Valenti* and Collin P Auwarter, Assistant Professor, and Research Specialists, Plant Sciences Department, North Dakota State University, Fargo, Fargo, ND 58105.

Weed control in cabbage is necessary for high yields and quality. However, the number of herbicides for weed control in cabbage is rather limited. This is especially true for broadleaf weed control. Clomazone, napropamide, and oxyfluorfen are the only herbicides registered for pre-emergence broadleaf weed control in cabbage. All three have factors associated with their use (e.g. carryover, availability, and short residual) that makes them less than ideal choices. In addition, Pyridate (WP formulation), the only herbicide registered for general post-emergence broadleaf control in cabbage is no longer marketed in the United States and supplies are now exhausted. Thus, a field trial was initiated to identify alternative weed control methods. Cabbage transplants were placed in two-row beds with a 2 ft row spacing and 1.5 ft between plants on May 22. Initial herbicide treatments consisted of herbicides applied just prior to transplanting or immediately following transplanting using a CO_2-pressurized sprayer equipped with 11001 flat fan nozzles with a spray volume of 20 GPA and a pressure of 40 psi. Four of the treatments also consisted of an application post-emergence to the crop and weeds.

Weed control evaluations indicated that common purslane, Venice mallow, and redroot pigweed control 3 WAT was greater than 85% when dimethenamid-P, oxyfluorfen (water-based formulation), or sulfentrazone were applied prior to transplanting. However, by 7 WAT, broadleaf weed control had dropped below an acceptable measure (85%) for all treatments except oxyfluorfen (water-based formulation) applied pre-transplant followed by oxyfluorfen (EC formation) applied post-emergence. The post-emergence application of oxyfluorfen caused visible injury to some of the cabbage leaves, but plants outgrew injury and had the greatest total yield from the two harvests. This was almost twice the yield from the untreated and approximately 25% more than the dimethenamid-P treatment, which was the second highest yielding treatment. Oxyfluorfen (water-based formulation) applied post-emergence caused less cabbage injury compared to the EC formulation, but because the initial application was at a lower rate, broadleaf weed pressure was much greater and many of the broadleaf weeds were beyond a controllable size at the time of the post-emergence application. This trial will be repeated in 2007 and additional treatments will be added to examine the potential of a postemergence application with the water-based formulation of oxyfluorfen.

USING MICRO-RATE TECHNOLOGY FOR EARLY-SEASON BROADLEAF WEED CONTROL IN ONION. James R. Loken* and Harlene M. Hatterman-Valenti, Graduate Research Assistant, and Assistant Professor, Plant Sciences Department, North Dakota State University, Fargo, ND 58105.

Onion (*Allium cepa* L.) is a crop with tremendous yield potential and economic return in North Dakota. However, due to the poor competitiveness of onion and the relatively short North Dakota growing season, weed control in onion has no margin for error. Weed competition is most damaging to yield as the onion plant grows to the two-leaf stage because of slow onion establishment to this point. Currently, no herbicides are labeled that provide broad-spectrum annual broadleaf weed control prior to the onion two-leaf stage. Thus, the importance of effective weed control in onion prior to the two-leaf stage is obvious.

Much like the multiple reduced-rate herbicide management practices (micro-rates) used for sugarbeet production in the Red River Valley, this project evaluated the effect of labeled and non-labeled herbicides applied at micro-rates to emerging annual broadleaf weeds, such as redroot pigweed and common lambsquarters, when onion ‘Teton’ was at growth stages less than two leaves.

The herbicides bromoxynil, oxyfluorfen, metribuzin, and acifluorfen were applied at rates 1/4, 1/8, and 1/16 the lowest labeled rate, and either two or three times at 1 wk intervals. A hand-weeded check and conventional herbicide application check were maintained for comparison to the micro-rates for overall weed control effectiveness. To determine herbicide micro-rate effectiveness, weed counts were taken seven days after each application in a 1 ft^2 quadrant and a mid-season visual evaluation was performed.

Three applications of bromoxynil or oxyfluorfen at the 1/4 rate (.0625 and .0125 lbs ai/A, respectively) provided excellent early-season broadleaf weed control. Two applications of bromoxynil at the 1/4 rate and three applications of oxyfluorfen at the 1/8 rate (.00625 lbs ai/A) provided poorer but acceptable early-season broadleaf weed control. Micro-rate applications of metribuzin and acifluorfen did not effectively control early-season broadleaf weeds.

DESIGN OF HERBICIDE APPLICATION EQUIPMENT FOR THE SMALL FRUIT AND VEGETABLE FARMS, Joe Masabni, Assistant Professor, Department of Horticulture, University of Kentucky, Princeton, KY, 42445.

Fruit and vegetable industries in Kentucky are small in terms of acreage and sales dollars relative to agronomic crops in Kentucky or to similar crops in the region. Many tobacco farmers took advantage of the tobacco buyout and are now raising fruits and vegetables. In addition, new farms have been established as non-traditional farmers are planting fruits, small fruits, or grapes. As a results, farms are small in size and can't invest in large or expensive spray equipment to justify the economic returns. Several herbicide spray equipment have been built and are being used at our research station as educational material to show our growers that a large capital is not needed to efficiently spray herbicides as part of their operation. The first equipment was modifying a plastic layer to include a nozzle directing the herbicide spray on top of the newly-formed raised bed, just before the plastic mulch is laid. This is useful for application of halosulfuron under plastic in tomato production, per label recommendation. This design is needed in Kentucky as our growers use equipments that shape the bed and lay plastic at the same time, unlike other equipments used elsewhere where bed formation and plastic laying are separate operations. The second equipment allows fruit and small fruit growers to apply herbicides by installing a 2-nozzle boom on the side of a gator. When used with a speedometer and an electric switch, one person can apply herbicides at a comfortable speed simply by driving a constant speed. The third equipment modifies a ZTR mower to include a pull-behind sprayer and a 2-nozzle boom attached to the front. This allows a grape grower to spray herbicides and mow the row middles in one pass.

EVALUATION OF HERBICIDES FOR USE IN PUMPKINS. John Masiunas and Abram Bicksler, Associate Professor and Graduate Research Assistant, Department of Natural Resources and Environmental Science, University of Illinois, 1201 West Gregory Dr., Urbana, IL 61801.

Weed management in jack o'lantern and processing pumpkins relieves on preemergence (PRE), surface applications of ethalfluralin and clomazone (Clomazone + ethalfluralin) after pumpkin planting and before crop emergence. Clomazone and ethalfluralin do not control eastern black nightshade or Amaranth species. Pumpkins can be injured if clomazone or ethalfluralin is washed into the crop zone. If broadleaf weeds or yellow nutsedge are problem than halosulfuron can be applied either PRE or postemergence (POST) after the crop is established. Halosulfuron is an acetolactase synthenase inhibitor (ALS-inhibitor) herbicide and problems have occurred with nightshade and water hemp biotype resistance to ALS-inhibitors. New options are needed to address resistance problems and provide pumpkin with diverse and economical tools for managing weeds in pumpkins. The objective of our study was to determine the efficacy and crop safety of standard and potential herbicide treatment for pumpkin. The treatments were: 1) weedy control; 2) clomazone + ethalfluralin at 1.3 + 0.42 kg/ha (PRE); 3) clomazone + ethalfluralin + halosulfuron at 1.3 + 0.42 + 0.069 kg/ha (PRE); 4) clomazone + ethalfluralin + halosulfuron at 0.88 + 0.27 + 0.069 kg/ha (PRE); 5) clomazone + ethalfluralin + halosulfuron/ clethodim at 1.3 + 0.42 + 0.069/ 0.107 kg/ha (PRE/POST); 6) halosulfuron/ halosulfuron + clethodim at 0.046/ 0.046 + 0.107 kg/ha (PRE/POST); 7) clomazone + ethalfluralin/ carfentazone at 1.3 + 0.42/ 0.105 (PRE/DPOST); 8) clomazone + ethalfluralin + flumioxazin at 1.3 + 0.42 + 0.105 (PRE); 9) clomazone + ethalfluralin/ flumioxazin at 1.3 + 0.42/ 0.105 kg/ha (PRE/ DPRE); 10) clomazone + ethalfluralin + halosulfuron/ flumioxazin at 1.3 + 0.42 + 0.069/ 0.105 kg/ha (PRE/ DPRE); 11) s-metolachlor at 1.4 kg/ha (PRE); 12) s-metolachlor + clomazone + ethalfluralin at 1.4 + 0.88 + 0.27 kg/ha (PRE); 13) s-metolachlor + halosulfuron at 1.4 + 0.069 kg/ha (PRE); 14) s-metolachlor + halosulfuron/ halosulfuron at 1.4 + 0.046/ 0.046 kg/ha (PRE/ POST); and 15) s-metolachlor + fomesafen at 1.4 + 0.28 kg/ha (PRE). The experiment was a randomized complete block design with four replications. The plots were 9 by 3.6 m and consisted of 1 row of 'Libby's Select' processing pumpkins and 1 row 'Howden' jack o'lantern pumpkins. The plants were spaced 1.5 m apart between rows and 0.9 m apart within the rows. On June 20, the pumpkins were seeded and the PRE herbicide treatments were applied with a CO_2 pressurized tractor-mounted sprayer delivering 281 L/ha. The POST treatments were applied with the same sprayer on July 6. All POST treatments included 0.5% crop oil concentrate. On July 27, we rated pumpkin injury on a scale of 0 (no injury) to 100 (complete plant depth). At the same time the number of pumpkin plants in each plot was counted. Weed control was rated on a scale of 0 (no control) to 100 (no weeds in the plots). On August 17, pumpkin injury and weed control were rated using the same scales. We harvested pumpkin cultivars separately. All mature (orange) pumpkin fruit were harvested, counted, and weighed. Data were analyzed using ANOVA and means separated using the Least Significance Difference Test ($\alpha = 0.05$). Clomazone + ethalfluralin + flumioxazin applied PRE caused greater than 50% injury to both pumpkin cultivars. When flumioxazin was applied as a PRE directed treatment there was no crop injury. Clethodim + halosulfuron POST applied alone caused 30 to 38% injury while clethodim applied POST did not cause significant pumpkin injury. On August 27 the 'Libby's Select' pumpkin treated with flumioxazin PRE had 22% injury while the 'Howden' pumpkin had 43% injury. No other herbicide treatment caused pumpkin injury. The dominant weeds were foxtails and large crabgrass (grass), common purslane, and *Amaranthus* species. On July 27, clomazone + ethalfluralin applied alone PRE did not control *Amaranthus* species and only provided 48 and 55% control of pigweed and grasses, respectively. S-metolachlor + fomesafen provided at least 90% weed control. Clomazone + ethalfluralin PRE followed by clethodim + halosulfuron POST controlled over 95% of the weeds. On August 17, s-metolachlor alone, s-metolachlor + fomesafen, or s-metholachlor + clomazone + ethalfluralin controlled greater 90% of the weeds. Clomazone + ethalfluralin PRE/ clethodim +

halosulfuron POST also controlled >95% weed control. At our site clomazone + ethalfluralin needs to be followed by POST applications of clethodim + halosulfuron to obtain consistent weed control but crop injury could be a probem. S-metolachlor will be a welcome addition to herbicides registered for pumpkin. It would provide good *Amaranthus*, grass, and common purslane control without injuring pumpkin. Further research is needed before flumioxazin PRE directed would have consistent weed control.

THE RESPONSE OF LINER GROWN ORNAMENTALS TO SELECTED HERBICIDES. Michael W. Marshall and Bernard H. Zandstra, Research Associate and Professor, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Weed competition, especially for light and water, retards growth, delays development, and impacts the ultimate marketability of transplanted liner grown ornamentals. Preemergence treatments, such as oryzalin plus isoxaben, followed by hand-weeding have been frequent common production practices. In addition to herbicide cost, hand-weeding increases the labor cost for the nursery. More herbicide are options are needed to reduce the expense of hand-weeding in liner production. Field studies were initiated at cooperator sites in 2006 located in west-central Michigan to evaluate weed control and response of liner grown ornamentals to various preemergence herbicides. Herbicide treatments included flumioxazin (sprayable formulation) applied at 0.29, 0.36, and 0.39 kg ha^{-1}, prodiamine applied at 1.68 and 3.36 kg ha^{-1}, isoxaben applied at 1.12 kg ha^{-1}, oxyfluorfen applied at 0.56 kg ha^{-1}, metolachlor applied at 2.13 kg ha^{-1}, dithiopyr applied at 1.12 kg ha^{-1}, mesotrione applied at 0.28 kg ha^{-1}, and an untreated control. Experimental design consisted of a randomized complete block with 3 or 4 replications with individual plot sizes of 1.8 by 6.1 m. The following ornamental species were evaluated including peony (*Paeonia officinalis* L. 'Rachel'), daylily (*Hemerocallis* 'Stella de Oro'), boxwood (*Buxus sempervirens* L.), and periwinkle (*Vinca minor* L.). Herbicides treatments were sprayed on April 14, 2006. Plant injury and weed control ratings were taken 4 and 8 weeks after treatment (WAT) on a 0 to 100% scale with 0 indicating no control or injury and 100 equal to weed or crop death. Periwinkle diameter was measured at 12 WAT. Plant injury, size, and weed control data were analyzed using ANOVA and means separated at the P = 0.05 level. Peonies and daylilies were severely injured at all rates of flumioxazin tested. However, both species eventually recovered and regrew by the end of the growing season. Oxyfluorfen (0.56 kg ha^{-1}) and prodiamine (1.68 kg ha^{-1}) treated peonies showed less than 13% injury at 2 MAT. Overall, isoxaben (1.12 kg ha^{-1}) plus prodiamine (1.68 kg ha^{-1}) and isoxaben plus metolachlor (2.13 kg ha^{-1}) were the safest treatments on peony and daylily. Horseweed (*Conyza canadensis* L.) and common groundsel (*Senecio vulgaris* L.) control was greater than 98% with oxyfluorfen (0.56 kg ha^{-1}), prodiamine (1.68 kg ha^{-1}), and flumioxazin treatments at 4 WAT. Boxwood showed very little injury or response to the combinations of oxyfluorfen, prodiamine, isoxaben, and metolachlor. In periwinkle, mesotrione provided excellent good to control of horseweed, common ragweed (*Ambrosia artemisiifolia* L.), spotted spurge (*Euphorbia maculate* L.), and common purslane (*Portulaca oleracea* L.) at 4 and 8 WAT with very low crop injury (<9%). Similar to peony and daylily, periwinkle was sensitive (>20% injury) to flumioxazin applied at the 0.29 and 0.36 kg ha^{-1} rates. In general, flumioxazin (sprayable formulation) showed the greatest injury to herbaceous perennials, such as peony, daylily, and periwinkle. The other products tested may provide an excellent fit for common weeds encountered in liner production weed control and have low crop injury potential.

TANK-MIXING STROBILURIN FUNGICIDES WITH METRIBUZIN, THIFENSULFURON AND RIMSULFURON IN TOMATO. Darren E. Robinson, Rob Nurse, Nader Soltani and Peter H. Sikkema, Assistant Professor, Department of Plant Agriculture, University of Guelph, Ridgetown, ON, N0P 2C0, Research Scientist, Agriculture and Agri-Food Canada, Harrow, ON, Research Associate and Assistant Professor, Department of Plant Agriculture, University of Guelph, Ridgetown, ON.

Trials were conducted at two locations in southwestern Ontario from 2004 to 2006 to compare the effect of tank-mixing strobilurin fungicides with tomato herbicides on weed control, tomato visual injury, and tomato yield. In each trial, one half of each plot was kept weed-free by handweeding to test for visual injury and tomato tolerance to herbicides alone. The other half of each plot was not hand-weeded to determine the level of weed control of each treatment, and the effect of competition on tomato yield. Treatments included rimsulfuron (15 and 30 g a.i. ha^{-1}), thifensulfuron (6 and 12 g a.i. ha^{-1}), metribuzin (150, 300, 600 g a.i. ha^{-1}), rimsulfuron+metribuzin (15+150 and 30+300 g a.i. ha^{-1}), or thifensulfuron+metribuzin (6+150 and 12+300 g a.i. ha^{-1}) alone or with either azoxystrobin (75 g a.i. ha^{-1}) or pyraclostrobin (110 g a.i. ha^{-1}). Untreated weed-free and weedy checks were included for comparison. Adding azoxystrobin or pyraclostrobin to rimsulfuron or metribuzin (150 and 300 g a.i. ha^{-1}) did not cause significant visual injury, however there was some injury (5%) when 600 g a.i. ha^{-1} Sencor was tank mixed with either fungicide. Adding azoxystrobin to thifensulfuron did not cause significant visual injury, while adding pyraclostrobin to thifensulfuron did result in commercially significant visual injury. Despite this, adding pyraclostrobin to thifensulfuron did not delay maturity or reduce yield. The addition of azoxystrobin or pyraclostrobin to metribuzin, thifensulfuron or rimsulfuron did not reduce weed control compared to the herbicides applied alone.

FACTORS INVOLVED IN SELECTING NOZZLE TIPS FOR PESTICIDE APPLICATION. Robert N. Klein, Jeffrey A. Golus and Amanda S. Cox, University of Nebraska, North Platte, NE.

The two main factors involved in selection of spray nozzle tips for pesticide application are pesticide efficacy and spray drift management. Other factors include carrier rate which may affect performance and drift but also affects cost of application because high spray volumes require more time spent in filling tanks, mixing, etc, and also more additives since most additives are as percent of carrier. Non-translocated pesticides in general require more spray coverage than translocated pesticides. Research was accomplished with a Sympatec Helos Vareo KF particle size analyzer with a R6 lens capable of detecting particle sizes in a range from 0.5 to 1230 microns. The nozzle tips are mounted on a boom with an electric linear actuator which moves the entire spray plum through the laser beam. Field tests are conducted to determine coverage both with Droplet Scan and visual control. For translocated herbicides the air induction spray nozzle tips are usually the best choice since they reduce the number of small droplets and herbicide efficacy is not reduced.

CONVENTIONAL AND AIR ASSIST SPRAYERS FOR WEED CONTROL IN SUGARBEET. Alan G. Dexter, John L. Luecke and Vernon L. Hofman, Professor and Research Specialist, Plant Sciences Department, North Dakota State University and University of Minnesota and Associate Professor, Agricultural and Biosystems Engineering Department, North Dakota State University, Fargo, ND 58105.

The objective of this research was to compare weed control from herbicides applied through conventional spray nozzles and herbicides applied though Shear Guard nozzles from Spray-Air USA Inc. The Shear Guard nozzles use high velocity air to atomize the liquid and blow the droplets towards the target plants. Five herbicide treatments were applied three times with the first treatment on cotyledon to two-leaf sugarbeet and the second and third treatments at six-to ten-day intervals. The micro-rate treatment was 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. Each herbicide rate was reduced by 25% for the 75% micro-rate treatment and by 50% for the 50% micro-rate treatment. The methylated seed oil rate was maintained at 1.5% v/v. The mid-rate treatment was desmedipham & phenmedipham & ethofumesate at 0.12 (time 1)/0.16 (time 2)/0.22 (time 3) 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 at 1.5% v/v. The conventional rate was 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. Amaranth, canola, flax, quinoa (*Chenopodium quinoa*) and sugarbeet were seeded in each plot. Bioassay species control and sugarbeet injury were evaluated at Prosper and Fargo, ND in 2005 and at Prosper, ND in 2006. The conventional sprayer was operated at 40 psi with XR8001 nozzles at 6 mph to deliver 5 gpa and with XR 80015 nozzles at 4.5 mph to deliver 10 gpa. The air assist sprayer was set to deliver 5 or 10 gpa at 4 mph using 10 inches of air in 2005 and to deliver 10 gpa at 4 mph using 10 or 20 inches of air in 2006.

Bioassy species control and sugarbeet injury in 2005 were not significantly affected by changing spray volume from 5 gpa to 10 gpa. Since spray volume had little effect on herbicide phytotoxicity in 2005, all treatments in 2006 were applied at 10 gpa. However, the air amount in 2006 was set at either 10 inches or 20 inches using a gauge on the sprayer while air amount was only set at 10 inches in 2005.

Averaged over all bioassy species and all herbicide rates, herbicides applied using 20 inches of air gave slightly better control than when applied using 10 inches of air. Herbicide treatments applied with the air assist sprayer gave better control of bioassy species and more sugarbeet injury than the same treatments applied with the conventional sprayer. The increased control of bioassy species with the air assist sprayer was not generally sufficient to allow a significant reduction in herbicide rate while maintaining weed control as compared to the conventional sprayer.

THE EFFECT OF NOZZLE TYPE AND PRESSURE ON POSTEMERGENCE WEED CONTROL.

Robert E. Wolf and Dallas E. Peterson, Associate Professor and Extension Specialist, Biological and Agricultural Engineering, and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

This study was conducted to evaluate herbicide efficacy comparing a conventional nozzle, two venturi type nozzles, a third nozzle designed to reduce drift while maintaining adequate efficacy, and the new VariTarget nozzle designed for use in variable rate application scenarios. The experiment included comparisons of a chamber style nozzle, the turbo flat-fan from Spraying Systems (TT); a venturi style, the AirMix from Greenleaf (AM); the Ultra LoDrift from Hypro (ULD), also a venturi style; the new design in 2005, a turbo-venturi combination, the turbo flat-fan induction also from Spraying Systems (TTI), and the VariTarget from Delavan Ag Spray (VT). Orifice size and operating pressure for each nozzle treatment were selected to deliver a spray volume of 94 L/ha at 9.6 km/h while maintaining a similar droplet size within the pressure range. With the VariTarget nozzle, the basic nozzle body remains the same while the spray cap is exchanged to affect the droplet spectra. For this experiment, all the nozzles were tested at a low pressure (276 kPa) and a high pressure (483 kPa). The flow rates were attained by selecting the following orifice sizes: TT11002, AM11002, ULD120015, and TTI110015. For the VariTarget, the black (low pressure) and blue (high pressure) caps were exchanged to match the droplets to the other four nozzles at the calibrated flow rate at 172 kPa. The applications were made with a tractor-mounted 3-point sprayer equipped with a 4-nozzle boom. Nozzles were spaced at 51 cm and located 51 cm above the target. Glyphosate at 0.17 kg ae/ha and paraquat at 0.25 kg ai/ha were used to compare efficacy on large crabgrass, ivyleaf morningglory, velvetleaf, common sunflower, sorghum, and corn. Sublethal herbicide rates were used to accentuate efficacy differences. Ammonium sulfate at 2% w/w was added to the glyphosate treatments and NIS at 0.25% v/v was added to the paraquat treatments. 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. Treatments were replicated three times and efficacy was evaluated 28 days after treatment.

Efficacy ratings show that very few significant differences and interactions were found among herbicide and nozzle variables. Species control varied between glyphosate and paraquat as would be expected. Glyphosate provided better control of corn, sorghum, and large crabgrass compared to paraquat, and was similarly poor for ivyleaf morningglory to slightly less than paraquat for sunflower control. Paraquat had significantly better control for the velvetleaf treatments. With glyphosate, the AM, TTI, and ULD were significantly better than the TT and VT at 276 kPa for sorghum control, but at 483 kPa, only the ULD was significantly less than the other spray tips. No other glyphosate and nozzle comparisons were significantly different for any species. With paraquat, the TT and AM at 276 kPa had significantly better velvetleaf control than the TTI, VT, and ULD. At 483 kPa, the AM, TT, and the ULD were all significantly better than the VT and TTI. No other species, nozzle type, and pressure interactions with paraquat were significantly different.

Several significant differences among nozzle and pressure treatments were found when compared across chemical for all species. Sunflower control was best overall in the nozzle comparisons with ivyleaf morningglory control the lowest of the species compared. Significant differences were found among nozzle and pressure treatments. In many of the comparisons, lower pressures tended to out perform the higher pressure treatments. Specific knowledge about the chemical, species, nozzle, and pressure parameters and the interactions are critical for maximum efficacy.

EFFICACY OF CORN HERBICIDES WHEN APPLIED WITH FLAT-FAN AND AIR-INDUCTION NOZZLES. Peter H. Sikkema, Lynette Brown, Christy Shropshire, Helmut Spieser, and Nader Soltani, Associate Professor, Research Technician, Research Technician, Extension Specialist, and Research Associate, University of Guelph Ridgetown Campus, Ridgetown, ON, Canada. N0P 2C0.

Twelve field experiments were conducted over a four-year (2002 to 2005) period to determine the influence of herbicide dose, nozzle type, spray volume and spray pressure on herbicide efficacy in field corn (*Zea mays* L.). Control of *Abutilon theophrasti* (velvetleaf), *Ambrosia artemisiifolia* (common ragweed), *Chenopodium album* (common lambsquarters), *Amaranthus powellii* (green pigweed) and *Echinochloa crus-galli* (barnyard grass) was improved with the use of full herbicide doses compared to half doses. The application of the full compared to the half herbicide dose resulted in an increase in control of 11 to 27% of *A. theophrasti*, *A. artemisiifolia* and *C. album* with bromoxynil (140 vs 280 g ha^{-1}), an increase in control of 20 to 28% of *A. powellii* and *C. album*, with glufosinate (200 vs 400 g ha^{-1}), an increase in the control of *A. theophrasti*, *A. artemisiifolia* and *C. album* of 11 to 19% with dicamba (150 vs 300 g ha^{-1}) and an increase in the control of *E. crus-galli* of 8 to 11% with nicosulfuron (12.5 vs 25 g ha^{-1}). Yield was increased by 9 to 15% for bromoxynil, 16 to 19% for glufosinate and 8% for nicosulfuron when the full herbicide dose was used. When applied at the manufacturer's recommended dose, flat fan (FF) nozzles compared to the air induction (AI) nozzles provided better control of *A. theophrasti*, *A. artemisiifolia* and *C. album* with bromoxynil, *A. artemisiifolia* and *C. album* with dicamba and *E. crus-galli* with nicosulfuron. Weed control with bromoxynil was the only herbicide that was affected by water carrier volume. By increasing spray pressure with an AI nozzle from 280 to 490 kPa, there was an improvement in the control of *A. theophrasti*, *A. artemisiifolia*, *C. album* with the application of bromoxynil and *E. crus-galli* with the application and nicosulfuron, and a 16% yield increase with bromoxynil. Overall, this study concludes that the optimum nozzle type, water carrier volume and spray pressure is herbicide and weed species specific.

CHEMICAL CONTROL OF COMMON MULLEIN. Walter H. Fick and Sandra Wick, Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506 and County Extension Agent, Smith Center, KS 66967.

Common mullein (*Verbascum thapsus* L.) is a biennial broadleaf found throughout much of North America. Originally introduced from Europe, this upright growing species with large flannel leaves grows in old fields, waste areas, roadsides, railroad rights-of-way, and abused pastures. Common mullein appears to be increasing following years of drought in the central Great Plains. A study was initiated in Smith County Kansas during 2006 to determine the efficacy of 13 herbicide treatments applied for common mullein control. Treatments were applied on April 21 to actively growing rosettes using a CO_2-powered 4-nozzle boom sprayer. All herbicides were applied with 0.25% (v/v) nonionic surfactant in a total spray solution of 187 L ha^{-1}. Individual plots were about 2 m wide by 7.6 m long. Treatments were applied using a randomized block design with four replications. Common mullein density was determined at the time of herbicide application using a 0.9-m belt transect taken down the center line of each plot. Density reduction was determined 8 and 14 weeks after treatment. Data were analyzed using analysis of variance and means separated at $P < 0.10$ using Fisher's protected LSD test. Eight weeks after treatment herbicides providing greater than 70% density reduction of common mullein included picloram + 2,4-D at 0.15 + 0.56 kg ha^{-1} (75%), aminopyralid at 0.09 kg ha^{-1} (76%), aminopyralid + 2,4-D at 0.09 + 0.75 kg ha^{-1} (92%), metsulfuron methyl a 0.01 kg ha^{-1} (91%), metsulfuron methyl + dicamba + 2,4-D at 0.01 + 0.14 + 0.4 kg ha^{-1} (77%), and picloram + fluroxypyr at 0.19 + 0.19 kg ha^{-1} (82%). Other treatments included picloram at 0.14 kg ha^{-1}, dicamba + 2,4-D at 0.28 + 0.8 kg ha^{-1}, 2,4-D at 2.1 kg ha^{-1}, diflufenzopyr + dicamba at 0.06 + 0.14 kg ha^{-1}, diflufenzopyr + dicamba + metsulfuron methyl at 0.06 + 0.14 + 0.01 kg ha^{-1}, triclopyr at 0.56 kg ha^{-1}, and triclopyr + fluroxypyr at 0.42 + 0.14 kg ha^{-1}. All treatments except 2,4-D and diflufenzopyr + dicamba + metsulfuron methyl provided greater than 70% density reduction of common mullein 14 weeks after treatment. Aminopyralid, aminopyralid + 2,4-D, metsulfuron methyl, and methsulfuron methyl + dicamba + 2,4-D provided greater than 90% control of common mullein.

EVALUATION OF HERBICIDES AND APPLICATION TIMINGS FOR LONG-TERM CONTROL OF SERICEA LESPEDEZA. Kevin Bradley, University of Missouri, Columbia, MO 65211.

Field trials were conducted in 2004 and 2005 to evaluate the effect of herbicides and application timings on late-season Sericea lespedeza (*Lespedeza cuneata* L.) control and Sericea lespedeza density one year after the initial herbicide applications (YAT). In both years, triclopyr + fluroxypyr at 0.28 + 0.09 and 0.38 + 0.13 lbs/A, picloram + fluroxypyr at 0.30 + 0.24 lbs/A, and metsulfuron at 0.02 lbs/A were applied at five distinct application timings; to early-, mid-, and late-vegetative stage Sericea lespedeza during the summer, and to pre- and full-bloom stage Sericea lespedeza during the late summer/early fall. In 2005, triclopyr at 0.75 lbs/A was also applied at each of these timings. In both years, all treatments provided greater than 90% late-season Sericea lespedeza control when applied at the early- or mid-vegetative stage application timings. All treatments except for metsulfuron also provided greater than 80% late-season Sericea control when applied at the late-vegetative or pre-bloom stage timings. There was no effect of application timing on Sericea lespedeza stem density 1 YAT, therefore results were combined across herbicide treatments. All herbicide treatments reduced Sericea lespedeza stem density from 53 to 86% when compared to untreated control plots 1 YAT. In both years, triclopyr + fluroxypyr at 0.38 + 0.13 lb/A and metsulfuron at 0.02 lbs/A provided similar reductions in Sericea lespedeza stem density 1 YAT. In 2005, triclopyr at 0.75 lbs/A provided similar reductions in Sericea lespedeza stem density 1 YAT as triclopyr + fluroxypyr at 0.38 + 0.13 lb/A and metsulfuron at 0.02 lbs/A. Picloram + fluroxypyr at 0.30 + 0.24 provided the lowest reductions in Sericea lespedeza stem density in both years.

EXPLORING ETHICS FOR MASTER NATURALISTS. Kathy S. Groves, Arboretum and Herbarium Technician, Cofrin Center for Biodiversity, University of Wisconsin – Green Bay Green Bay, Wisconsin.

Environmental education programs are often based upon the idea that sharing knowledge and love for nature will lead others to care for wilderness areas. While this is often true, economic considerations tend to drive decisions regarding land. This has lead to continual abuse of both public and private lands. The answer to this dilemma is often – more environmental education. While the volume of environmental education may indeed be part of the solution, the content must also include the development of a land ethic. As defined by Aldo Leopold (1949) the land ethic "..reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land. Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity". This session will explore ways to identify individual attitudes toward conservation, discuss various conservation philosophies, and explore techniques for helping others develop a land ethic.

COMMON MULLEIN CONTROL IN SOUTH-CENTRAL NEBRASKA. Jennifer M. Rees, Fred W. Roeth, Alex R. Martin, Irvin Schleufer, and Mark Bernards, Extension Educator, Professor, Professor, Research Technician, and Assistant Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE 68583-0915

Common mullein (*Verbascum thapsus* L.) is a biennial forb that produces a rosette the first year and a flowering stem the second. The plant is found throughout Nebraska primarily in road-side ditches, waste sites, and abused pastures. A combination of drought, overgrazing, and improper timing of control have resulted in increased incidence of mullein throughout Nebraska, particularly in south-central and western Nebraska. Trials were conducted in the fall of 2004 and spring of 2005 in two producers' pastures to determine the effect of eight fall and spring applied treatments on mullein control. Fall treatments were applied October 18, 2004 and spring treatments were applied April 20, 2005. The treatments included Tordon 22K (16 oz/A), Grazon P+D (3 pt/A), Surmount (2 pt/A), Overdrive (6 oz/A), Overdrive (4 oz/A) + Cimarron (0.25 oz/A), Cimarron (0.3 oz/A), Cimarron (0.2 oz/A) + 2,4-D Ester (2 pt/A), and Clarity (0.5 pt/A) + 2,4-D Ester (2 pt/A). Each treatment solution contained 0.25% v/v NIS and 2% v/v AMS and was applied with a ground sprayer at 20 gallons/acre. Plots were evaluated (counted plants) in early June to determine percent control. Over 90% of common mullein was controlled by Tordon and Surmount applied in the fall. Control of common mullein exceeded 90% with all herbicide treatments applied in the spring.

NOVEL WATER CONDITIONING AGENTS FOR GLYPHOSATE. Donald Penner, Professor, Michigan State University, East Lansing, MI 48824.

Water conditioners are adjuvants that may such as low amounts of fertilizer, like diammonium sulfate, to complex mixtures designed to accomplish several adjuvant functions. Cations such as Ca^{++}, Mg^{++}, and Fe^{+++}, are commonly found in hard water. At high concentration Na^{+} can also be a problem. These readily exchange in the spray tanks with the positively charged counterion of negatively charged herbicides. At high concentration Na^{+} can also be a problem. The resulting salt from the cations in hard water is generally less soluble and less readily absorbed by plant foliage. Studies with glyphosate applied in hard water have shown that a water conditioner, likely diammonium sulfate, increased control of all weed species tested. However, the magnitude of response differed markedly. The need for water conditioners when applying herbicides in hard water is not limited to glyphosate. Many herbicides that are weak acids benefit from the inclusion of a water conditioner for overcoming hard water problems. Water conditioners act by a) providing a positively charged counterion, like NH_4^{+}, in overwhelming amounts, that form salts with the weakly acidic herbicide that can be readily absorbed by plant foliage, or b) by chelating or sequestering the hard water cations so they are not able to form salts with the weakly acidic herbicide. Products sold as water conditioners are not all equal. Diammonium sulfate (AMS) at 2% in the spray tank has been considered the standard. Other ammonium salts that are effective are diammonium phosphate and ammonium nitrate. Novel materials that have been evaluated for their water conditioning properties include EDTA, citric acid, sulfuric acid, hydrochloric acid, N-formamylsulfamate also called monocarbamide dihydrogensulfate and 1-aminomethanamide dihydrogen tetraoxosulfate (AMADS).

ACTIVATOR ADJUVANTS: TYPES AND USE PATTERNS. John D. Nalewaja, Professor Emeritus, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105-5051.

Introduction

This discussion will be limited to surfactants, oils, and blend adjuvants. Salt adjuvants used to overcome antagonism by spray carrier ions or to directly enhance efficacy will be discussed by others. An adjuvant generally is required to obtain the full potential of a postemergence herbicide or to allow their full potential under various application practices. For example, the efficacy of several sulfonylurea herbicides was increased four-fold when applied with methylated seed oil and two-fold with petroleum oil when compared to a nonionic surfactant (Roehl 1992). Not all adjuvants within a classification type are equal in efficacy. There are many types of surfactants and oils so their efficacy can vary by product. Most commercial products were selected for efficacy but may differ in effectiveness depending on the herbicide. Some factors influencing adjuvant efficacy will be discussed to indicate characteristics to be considered during formulation of commercial products and to indicate that one commercial product may not maximize efficacy of all herbicides.

Postemergent herbicide efficacy, first, requires spray retention by weeds and, second, herbicide absorption from the spray deposit by the weed. These two processes are influenced by many spray, plant, herbicide, and environmental conditions. Spray droplet retention is influenced by adjuvant type, spray water volume, spray droplet size, plant leaf wax characteristics, and leaf orientation, as is well known. The role of various adjuvants in herbicide absorption is less understood. Absorption of a herbicide from the spray deposit is complex and involves an adjuvant's ability to dissolve the herbicide and plant wax, to make contact with the leaf surface, and to leave a spray deposit with physical and chemical characteristics conducive to herbicide diffusion into the weed. Physical spray deposit characteristics include degree of contact with the leaf waxes for direct passage of the herbicide into the leaf and a deposit mass to provide adequate herbicide concentration for absorption that result in a toxic response. The chemical composition of a spray deposit required for absorption is a complex solubility interrelationship among the herbicide, adjuvant, and plant cuticle, as well as the minerals in the spray carrier water.

The role of surfactants, oils, and blend adjuvants in spray retention and herbicide efficacy will be discussed using specific examples. These examples are to present basic concepts for specific herbicides and adjuvants with their solubility characteristics and may not always be applicable to other herbicides and adjuvants.

Surfactants

Surfactants by definition are surface active agents that reduce interfacial tension and thus would reduce the surface tension of water used as a spray carrier. Water with a low surface tension will improve water's ability to wet the lipid surfaces of leaves for better spray droplet retention and better contact of the droplet deposit with the leaf surface. However, surfactants differ in their ability to enhance spray retention. Surfactants with a low dynamic surface tension were important to good spray retention (Holloway 1995). Spray droplets as they leave the sprayer nozzle are mixing vigorously and the time between droplet formation and contact with the target is too short for the droplet mixture to reach a static state. Thus, surfactants that give a low surface tension under dynamic conditions are best for spray retention. The ability of a surfactant to give a low dynamic surface tension depends on the surfactant's chemistry, molecular size, and concentration in the spray solution.

Originally surfactants were believed to function mainly to enhance spray retention, so a concentration of 0.25% v/v generally was considered adequate because that would exceed the critical micelle concentration (CMC). CMC is the concentration at which static surface tension is at a minimum for most surfactants. However, this did not consider that a low dynamic surface tension is needed for good spray retention. I (Nalewaja) once stated that surfactants generally are for spray retention so usage should be on a percentage basis and oils are mainly for absorption so their usage should be on a per area basis. The assumption was that sprays applied on a percentage surfactant basis would result in the same retention regardless of spray volume. The function of oils was considered mainly for herbicide absorption so application on an area basis would give the proper amount for herbicide absorption regardless of spray volume.

Spray retention enhancement depends upon surfactant chemistry and its hydrophilic-lipophilic balance (HLB), concentration in the spray solution, and leaf wax characteristics of the plant (Bruns and Nalewaja 1998; Manthey et al. 1998). Low HLB surfactants generally give greater spray retention than those with a high HLB but the response depends on the surfactant chemistry and plant species involved. Spray retention generally increased as surfactant concentration increased, but increasing a low-HLB secondary-alcohol surfactant concentration to 4% v/v decreased retention on easy-to-wet redroot pigweed.

Spray retention certainly is essential for foliar-applied herbicide efficacy, but surfactants giving high retention were not always the most efficacious (Manthey et al. 1998). This indicates that the surfactant's chemical characteristics that enhance herbicide absorption are more important for efficacy than small differences in spray retention.

Surfactants have been important for herbicide efficacy in many literature reports. High HLB surfactants with similar lipophiles generally are more effective than low HLB surfactants for water-soluble herbicides and lower HLB surfactants are more effective for oil-soluble herbicides (Green 2005; Nalewaja and Matysiak 2001; Stock and Holloway 1993). These results indicate that surfactants had a function as solvents to aid in herbicide absorption. The importance of herbicide solubility in a surfactant was demonstrated by herbicide crystals remaining in deposits with certain surfactants but not others (Nalewaja and Matysiak 2000; Woznica et al. 2003). Sulfonylurea herbicides were more effective in a spray with high pH than low pH (Green 2005; Nalewaja and Matysiak 2001; Woznica et al. 2000). High HLB surfactants were more effective at high pH than low pH because at high pH nicosulfuron was more soluble in the high HLB surfactants (Green and Cahill 2006). Solubility of nicosulfuron in the surfactant was important for efficacy. Crystals were observed in spray deposits with certain non-effective surfactants, which were assumed to be the herbicide (Nalewaja and Matysiak 2000; Woznica et al. 2000; Woznica et al. 2003).

Surfactants, depending upon their chemistry and other materials in the spray mixture, influence the characteristics of the spray droplet deposit (Green and Cahill 2006). A spray deposit of glyphosate, a water soluble herbicide, and high HLB linear alcohol ethoxylates left relatively thick deposits with good leaf surface contact that was efficacious (Nalewaja and Matysiak 1995). Surfactants that caused extensive droplet spread were not effective with glyphosate. These spreading surfactants are more lipophilic than the non-spreaders and would not be good solvents for highly water-soluble glyphosate, thereby reducing absorption. However, the importance of a concentrated deposit over a small area to glyphosate efficacy has been shown with concentrated droplets (Cramner and Linscott 1990) and low spray volumes (Ramsdale and Messersmith 2002; Ramsdale et al. 2003).

Conversely, efficacy of oil-soluble fluazifop was less influenced by deposit spread (Nalewaja and Matysiak 1995). The less viscous 6-10 carbon alcohol ethoxylates were generally more efficacious with fluazifop than those with 16-18 carbon. Surfactants that give an amorphous spray deposit with good leaf surface contact generally are positive for efficacy of water-soluble herbicides.

Minerals in the spray carrier water or fertilizer added to the spray mixture generally lower the optimum surfactant HLB for efficacy (Nalewaja et al. 2001). These minerals appear to cause a coarse granular deposit that may prevent good herbicide diffusion through the deposit to the leaf surface. Surfactants with a low HLB are less viscous, resulting in a deposit that is more liquid through which the herbicide may better diffuse for absorption and efficacy (Nalewaja and Matysiak 2000).

Oils

Oil adjuvants are petroleum or vegetable oil in origin. Oil adjuvants vary greatly. Petroleum oil adjuvants are selected for non-toxicity to plants and can vary in chemical composition, viscosity and emulsifier content. Petroleum oils with 17% or more of a specific emulsifier were called “crop oil concentrate” because they have equal efficacy with atrazine when used at 2.3 L/ha compared to 9.2 L/ha required for petroleum oil with 5% or less emulsifier. Vegetable oils are from several plant sources and are either refined oil or esterified oil, usually the methyl ester.

Petroleum and vegetable oil efficacy with nicosulfuron generally increased as emulsifier percentage in the adjuvant increased from 3 to 25 or 35% (Nalewaja et al. 1995). However, percentage emulsifier in the methylated oil adjuvant did not greatly influence efficacy. Thus, methylated oil was effective independent of the emulsifier and would only need enough emulsifier for good dispersion in the spray carrier water.

Spray retention generally increased as the percentage of oil adjuvants in the spray mixture increased (Bruns and Nalewaja 1998; Hall et al. 1997; Western et al. 1998). However, spray retention with an oil adjuvant was less with oil at 4% v/v than with surfactants at 0.25% v/v (Bruns and Nalewaja 1998). Spray retention for oil adjuvants, all with 15% v/v of the same emulsifier, generally was esterified vegetable > vegetable > petroleum oil, (Bruns and Nalewaja 1998). Thus, the function of oil adjuvants is more to aid absorption than spray retention. The above results were for adjuvants in water without herbicide, but addition of a sulfonylurea herbicide did not influence retention. Oils increase in effectiveness with increased concentration in the spray mixture so they usually are applied on an area basis and in amounts that give high percentages in the spray mixture, especially at low spray volumes.

Petroleum oils used with herbicides have a 70 or 110 second viscosity. These oils were used commonly as horticultural spray oils and were adapted for herbicide use because they were not toxic to plant tissue (Nalewaja 2002). Oil viscosity influenced efficacy of sethoxydim (Matysiak and Nalewaja 1999). Sethoxydim applied at 10 C was more efficacious when mixed with 70 second petroleum oil adjuvants than 110 second oil but the opposite occurred when applied at 25 C. High temperature appeared to cause the low viscosity oil to spread excessively, thereby reducing the sethoxydim deposit concentration for absorption. Conversely, at low temperature the high viscosity oil did not spread and gave poor droplet deposit contact with the leaf surface. Esterified vegetable oil was equally effective at both temperatures, providing deposits that spread with close contact to the leaf surface. The greater solvency of esterified oils than petroleum oils in cuticle may account for their efficacy, even though the deposits were thin (Manthey and Nalewaja 1992). Esterified vegetable oil was more efficacious than petroleum oils, regardless of temperature.

Solvency and viscosity characteristics of oil adjuvants do not always relate to efficacy with all herbicides (Nalewaja 1994). If cuticle solvency was primary to herbicide absorption, then esterified vegetable oil adjuvants would be most effective with all herbicides. However, for grass control, methylated sunflower oil was only equal to petroleum oil with diclofop, quizalofop, and fluazifop, but the methylated oil was more effective with sethoxydim, fenoxaprop and haloxyfop. For broadleaf control, methylated oil was more effective than petroleum oil with acifluorfen, fomesafen and imazaquin, equally effective with bentazon, and less effective with lactofen. Sunflower oil was less effective than petroleum oil with all of these grass control herbicides, but equal with sethoxydim. For broadleaf control with lactofen, a soybean oil adjuvant was only less effective than petroleum oil. These oils all had the same emulsifier (15% Atplus 300F). In general, methylated vegetable oils were equally or more effective than petroleum oil. Vegetable oils were equal to petroleum oil, except less effective with quizalofop, fluazifop, and lactofen.

2006 North Central Weed Science Society Proceedings 61:151.

Blended adjuvants

Many adjuvants are blends. All oil adjuvants are blended with an emulsifier but are not considered blend adjuvants. Basic blend adjuvant was first used to define a blend of fertilizer, surfactant, and basic pH enhancer. Basic blend also would apply to the high pH, oil, fertilizer, and surfactant adjuvants presently on the market. The term acid blend could be used for the low pH fertilizer blends used for glyphosate. Further, pH-lowering oils are marketed to protonate herbicides to overcome antagonistic salt herbicides or minerals in the spray water (Wanamarta et al. 1989). Blend adjuvant classification perhaps should be limited to those that are intended to change pH for efficacy. For example, when the blend is designed to raise pH it could be a basic blend and when to lower pH an acidic blend. Many adjuvants contain ammonium sulfate or other nitrogen compounds with or without a surfactant. These have been classified as nitrogen adjuvants.

Basic blends came into existence with nicosulfuron because the high pH helped to dissolve the herbicide for enhanced efficacy in presence of an ammonium salt and a surfactant specific to the high pH and salts in the adjuvant (Nalewaja et al. 2001). High HLB of the surfactant was positive to efficacy of nicosulfuron, which is water soluble at high pH (Green 2005). However, with ammonium salts as in a basic blend adjuvant, the optimum HLB was lower than without the salts (Nalewaja et al. 2001). Thus, the efficacy of a basic blend would depend upon the specific combinations of surfactant type, ammonium salt, and pH enhancer.

Adjuvant use patterns

The concept that oils are to be applied on an area basis and surfactants on a percentage basis may not be proper unless application on an area basis was independent of spray volume. The number of experiments that concurrently test various amounts of adjuvant and spray volumes is limited. One experiment was found where methylated vegetable oil and petroleum oil adjuvants at 0.4 and 0.8 L/ha were equally as effective with sulfonylureas when applied in 80 or 160 L/ha (Roehl 1992). Efficacy was greater at 0.8 than 0.4 L/ha for both oils.

Adjuvant percentage concentration decreases as spray volume increases when adjuvants are applied on an area basis. Thus, low spray volume would give a high percentage adjuvant in the spray without increasing the cost for adjuvant. Adjuvants applied on a percentage basis would require more adjuvant as volumes increase. Most research indicates that herbicide efficacy increased as oil adjuvant concentration in the spray increased because of a decrease in spray volume, regardless if spray volume was reduced by increased sprayer travel speed or a reduction in nozzle size (Nalewaja and Ahrens 1998; Ramsdale and Nalewaja 2001). Imazamox efficacy increased as percentage of methylated vegetable oil or nonionic surfactant increased independent of spray volume. Most reports indicate that increasing percentage of surfactant, oil, or basic blend adjuvant increases efficacy (Zollinger and Howatt 2005). In the previous research, the conclusion was that oil adjuvants should be applied on an area basis because control was greatest when applied at 1.75 L/ha. However, this also would have been the highest percentage if expressed as a percentage. Since surfactants and oil both function in spray retention and absorption, probably all adjuvants should be applied on a percentage basis. The percentages would need to be selected for the specific adjuvant. High percentages can be attained by using low spray volume without increasing the total adjuvant amount applied or cost.

Low spray volume of 47 L/ha has been equally or more effective than higher spray volumes for most herbicides (Manthey and Nalewaja 1992; Ramsdale and Messersmith 2002; Ramsdale et al. 2003). Low spray volume originally were considered important to glyphosate efficacy because it would reduce the ratio between glyphosate and antagonistic cations in the spray solution. However, low spray volumes have enhanced glyphosate efficacy, probably because of higher glyphosate concentration in the deposit (Cramner and Linscott 1990) and imazethapyr (Ramsdale and Messersmith 2002). It would seem logical that the highly concentrated droplets with low volume would be positive for translocated herbicides, but low spray volume also was positive to paraquat, a contact herbicide (unpublished NDSU data). Low spray volumes usually imply use of small nozzles that give small droplets, which are subject to off-target drift. However, nozzles have been developed that produce ‘large’ droplets at low volume. These larger droplets have been equally effective as small droplets for glyphosate in low spray volumes (Ramsdale et al. 2003).

Adjuvants are important to efficacy of postemergence herbicides. There are many types of surfactants and oils and their characteristics greatly influence efficacy. Commercial adjuvants have been selected for efficacy, but adjuvant types differ in effectiveness for different herbicides. These adjuvants need to be selected based upon their specific efficacies. For example, atrazine in mixture with nicosulfuron should be applied with a methylated vegetable oil that is effective with both herbicides. A basic blend adjuvant would be slightly more effective with nicosulfuron, but less effective with atrazine. Adjuvants, surfactants, oils, and blends generally increase herbicide efficacy with an increase in concentration. The economics for the proper concentration has not been established through research. Over time growers or adjuvant producers through experience usually establish an acceptable use rate.

Literature Cited

Bruns, D. E. and J. D. Nalewaja. 1998. Spray retention is affected by spray parameters, species, and adjuvants. pp. 107-119 *in* J. D. Nalewaja, G. R. Goss, and R. S. Tann (ed.). Pesticide Formulation and Application Systems. ASTM STP 1347, West Conshohocken, PA.

Cramner, J. R. and L. D. Linscott. 1990. Droplet makeup and the effect on phytotoxicity of glyphosate on velvetleaf. Weed Sci. 38:406-410.

Green, J. M. 2005. Effect of nonylphenol ethoxylates on the biological activity of three herbicides with different water solubilization. Weed Technol. 19:468-475.

Green, J. M. 2005. Increasing and decreasing pH to enhance the biological activity of nicosulfuron. Weed Technol. 19:468-475.

Green, J. M. and W. R. Cahill. 2006. Enhancing the biological activity of nicosulfuron with pH adjusters. Weed Technol. 17:338-345.

Hall, K. J., P. J. Holloway, and D. Stock. 1997. Factors affecting the efficacy of spray delivery onto foliage using oil-based adjuvants. Aspects Applied Biol. 48:113-120.

Halloway, P. J. 1995. Adjuvants for foliage-applied agrochemicals; the need for more science not serendipity. pp. 167-176 *in* R. E. Gaslin, (ed.). 4th International Symposium on Adjuvants for Agrochemicals. Rotorua, NZ.

Manthey, F. A., M. Czajka, and J. D. Nalewaja. 1995. Nonionic surfactant properties affect enhancement of herbicides. pp. 278-287 *in* F. R. Hall P. D. Berger, and H. M. Collins (ed.). Pesticide Formulations and Application Systems. ASTM STP 1234, West Conshohocken, PA.

Manthey, F. A. and J. D. Nalewaja. 1992. Relative wax solubility and phytotoxicity of oil to green foxtail. pp. 464-470 *in* C. J. Foy (ed.). Adjuvants for Agrochemicals. CRC Press, Boca Raton, FL.

Manthey, F. A., Z. Woznica, and P. Milkowski. 1998. Surfactants differ in their effect on droplet retention, droplet spread, and herbicide efficacy. pp. 120-130 *in* J. D. Nalewaja, G. R. Goss, and R. S. Tann (ed.). Pesticide Formulation and Application Systems. ASTM STP 1347, West Conshohocken, PA.

Matysiak, R. and J. D. Nalewaja. 1999. Temperature and UV light affect sethoxydim phytotoxicity. Weed Technol. 13:94-99.

Nalewaja, J. D. 1994. Esterified seed oil adjuvants. Proc. North Central Weed Sci. Soc. 49:149-156.

Nalewaja, J. D. and R. Matysiak. 1995. Ethoxylated linear alcohol surfactants affect glyphosate and fluazifop absorption and efficacy. pp. 291-296 *in* R. E. Gaskin (ed.). 4th International Symposium on Adjuvants for Agrochemicals. Rotorua, NZ

Nalewaja, J. D., T. Praczyk, and R. Matysiak. 1995. Surfactants and oil adjuvants with nicosulfuron. Weed Technol. 9:689-695.

Nalewaja, J. D. and W. H. Ahrens. 1998. Adjuvants and spray volume affect herbicide efficacy. pp. 434-441 *in* P. M. McMullan (ed.). 5th International Symposium of Adjuvants for Agrochemicals. Memphis, TN.

Nalewaja, J. D. and R. Matysiak. 2000. Spray deposit from nicosulfuron with salts that affect efficacy. Weed Technol. 14:740-749.

Nalewaja, J. D. and R. Matysiak. 2001. Nicosulfuron response to adjuvants, salts, and spray volume. pp. 304-314 *in* H. deRuiter (ed.). 6th International Symposium on Agrochemicals. Amsterdam, Netherlands.

Nalewaja, J. D., R. Matysiak, and Z. Woznica. 2001. Optimum surfactant HLB for nicosulfuron in salt deposits. pp. 131-140 *in* A. K. Viets, R. S. Tann, and J. C. Mueninghoff (ed.). Pesticide Formulation and Application Systems. ASTM STP 1400, Conshohocken, PA.

Nalewaja, J. D. 2002. Oils as and with herbicides. pp. 290-300 *in* G.A.C. Beattie, D. M. Watson, M. L. Stevens, D. J. Rae, and R. N. Spooner-Hart (ed.). Spray Oils Beyond 2000. Univ. Western Sydney, Australia.

Ramsdale, B. K. and J. D. Nalewaja. 2001. Adjuvants influence herbicide efficacy at low spray volumes. pp. 224-229 *in* H. deRuiter (ed.). 6th International Symposium on Adjuvants for Agrochemicals. Amsterdam, Netherlands.

Ramsdale, B. K. and C. G. Messersmith. 2002. Adjuvant and herbicide concentration in spray droplets influence phytotoxicity. Weed Technol. 16:631-637.

Ramsdale, B. K., C. G. Messersmith, and J. D. Nalewaja. 2003. Spray volume, formulation, ammonium sulfate, and nozzle effect on glyphosate efficacy. Weed Technol. 17:589-598.

Roehl, S. R. 1992. Adjuvants with sulfonylurea herbicides in corn. M.S. Thesis, North Dakota State University, Fargo.

Stock, D. J. and P. J. Holloway. 1993. Possible mechanism for surfactant induced foliar uptake of agrochemicals. Pesticide Sci. 38:165-177.

Wanamarta, G. S., D. Penner, and J. J. Kells. 1989. The basis of bentazon antagonism on sethoxydim absorption and activity. Weed Sci. 37:400-404.

Western, N. M., D. Coupland, V. Breeze, and M. Bieswal. 1998. Evaluation of different vegetable oil as possible replacements for mineral oil adjuvants. pp. 352-358 *in* P. M. McMullan, (ed.). 5th International Symposium on Adjuvants for Agrochemicals. Memphis, TN.

Woznica, Z., B. L. deVilliers, C. G. Messersmith, and J. D. Nalewaja. 2000. Calcium nitrate as a potential adjuvant for herbicides. pp. 75-81 *in* H. deRuiter (ed.). 6th International Symposium on adjuvants for agrochemicals. Amsterdam, Netherlands.

Woznica, Z., J. D. Nalewaja, C. G. Messersmith, and P. Milkowski. 2003. Quinclorac efficacy is affected by adjuvants and spray carrier water. Weed Technol. 17:582-588.

Zollinger, R. K. and K. A. Howatt. 2005. Influence of adjuvants on weed control from tribenuron. pp. 115-121 *in* M. Salyani, and G. Linder (ed.). Pesticide Formulations and Delivery Systems. ASTM STP 1470. West Conshohocken, Pa.

NON-TRADITIONAL ACTIVATOR ADJUVANTS. Patrick M. McMullan, Manager – Agronomic Research, agroTECHNOLOGY Research, Inc., Memphis, TN 38120.

The activator adjuvants traditionally used by producers are either nonionic surfactants/wetting agents (NIS), crop oil concentrates (COC), or methylated seed oil concentrates (MSOC). However, several new adjuvant types have been introduced to the marketplace which do not fit the traditional definition of the afore-mentioned adjuvants. Methylated seed oil/organosilicone blend adjuvants have been available in the marketplace for about 10 years now. These adjuvants are typically used at 0.5% v/v or 1 quart/acre, which is one-half the typical use rate of a MSOC. The organosilicone surfactant contained in the formulation improves the wetting ability of the adjuvant and helps to account for the lower use rate of the adjuvant. High surfactant oil concentrates (HSOC) are similar to COC and MSO adjuvants in terms of composition but the ratio of oil: emulsifier is changed, which allows for a use rate of ½ that of their traditional counterparts. The decreased oil: emulsifier ratio (going from 83:17 to 60:40 in the case of crop oil adjuvants) creates smaller oil droplets in the spray solution (the emulsion often changes from a milky white to a bluish-white color). The smaller oil droplets can create a more uniform coverage on target surfaces and increase in herbicide uptake. The lower use rate of HSOCs has several advantages including potential lower cost to the producer, less adjuvant required by the producer, and lower storage and shipping charges to the adjuvant formulator/distributor. High fructose corn syrup can increase herbicide efficacy. When applied alone it is less effective than all other adjuvant types available to the producer. However, when applied in combination with conventional adjuvants, efficacy of many herbicides can be increased, especially on grass species. Polyacrylamide polymers have traditionally been used in drift control adjuvants to reduce drift potential of sprays. However, research with polyacrylamides has shown that polyacrylamides are also effective in increasing herbicide efficacy. Molecular weight of the polymers does not appear to influence the efficacy. Possible reasons for the increased efficacy may be due to reduced bounce of spray droplets, improved adhesion of droplets to leaf surfaces, and increased cuticle penetration. Ethoxylated triglycerides (ETG) are a new adjuvant type, introduced to the marketplace in 2006. These adjuvants are seed oil based (canola, soybean, cotton) and are used at rates much lower than traditional oil-based adjuvants (around 0.25% v/v). ETGs enhance herbicide efficacy similar to that of traditional COCs. Due to the ethoxylation of the triglyceride, ETGs can reduce surface tension. However, the surface tension is higher than to that of traditional NIS and are poor wetters. ETGs are poor solvents and not overly effective in disruption of the plant cuticle. A possible mode of action for enhancing herbicide efficacy is excess surface concentration (more of the ETG on the leaf surface edge of the spray droplet).

GROWER PERSPECTIVE ON ADJUVANT USE AND ADJUVANT DATA AVAILABILITY.
Douglas L. Schmale, Dryland Grain Producer, Lodgepole, NE 69149.

For many growers, the word adjuvant is synonymous with the word surfactant, and would be defined as “the stuff my chemical supplier tells me to add to the tank”. It is difficult for producers to become more sophisticated in the use of adjuvants as reliable, easily accessible information on adjuvant composition and performance is not generally available. The concept of choosing a specific adjuvant, based on desired characteristics for a particular use, is also not widely presented to growers.

ADJUVANT PERSPECTIVES - UNIVERSITY. Rich Zollinger, Extension Weed Specialist, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105-5051.

The U.S. EPA does not regulate adjuvants as pesticides and approximately 1000 chemicals are exempt from EPA regulation. Hence, thousands of name brand adjuvants exist today. Lack of regulation, profitability in adjuvant production and marketing, nonproprietary status of adjuvants, and complexity of the interaction between plant, herbicide, environment, water quality, and adjuvant has caused a pervasive attitude of confusion for adjuvant selection among growers. Growers use three main criteria in adjuvant selection: cost, effectiveness, and crop safety. With the exception of cost, unbiased information on effectiveness and crop safety are rarely available for most commercial adjuvants. Choosing the best adjuvant for each specific condition may be difficult. Other factors contributing to grower confusion on adjuvant selection are unfamiliarity and non-standardizing of adjuvant active ingredients, number and function of adjuvant classes, specified rate, vague and contradictory recommendations on pesticide and adjuvant labels, unsubstantiated and unguaranteed manufacturer claims, testimonials, unfamiliar adjuvant terminology in product descriptions, use of obscure adjuvants with herbicides in scientific research and publications, lack of unbiased research, and lack of adjuvant specific education in extension programs and publications. Another condition which minimizes the importance of adjuvant selection is liability for herbicide nonperformance. Rarely do adjuvant manufacturers become involved in grower complaints of pesticide nonperformance. Advancement has been made to reduce grower confusion with adjuvant selection. Chemical companies have published approved adjuvant lists and have issued guidelines to manufacturers that set minimum requirements to qualify adjuvants for use with herbicides. Pesticide companies are increasing the study of adjuvants in discovery screens of pesticides. Registered herbicides are beginning to be marketed with an effective adjuvant either in the herbicide formulation or packaged in a different container and sold with the formulated herbicide. University adjuvant research is limited but shows variability in herbicide enhancement from adjuvants and has influenced herbicide label wording and recommendations.

ENHANCING WEED CONTROL THROUGH ADJUVANT TECHNOLOGY, A DISTRIBUTORS PERSPECTIVE. Bob Herzfeld, Adjuvant Business Manager, Agriliance LLC, St. Paul, MN 55164.

Three areas of the agricultural adjuvant business will be covered from the perspective of distribution: what adjuvants mean to distributors, distributor's expectations of pesticide manufacturers, and industry (agricultural pesticide manufacturers, dealers and growers) expectations of adjuvant distributors.

Adjuvants provide an avenue for distributors to add value to product offerings to their customers, either dealers or growers. This value comes as increased performance of pesticides and solving stewardship challenges such as spray drift, tank contamination and application errors. Adjuvants significantly differentiate manufacturers active ingredients and themselves from competition. In short, the adjuvant business for distributors helps them maximize the full potential of their customer's and their own investment.

Pesticide manufacturers can greatly benefit from working closer with the adjuvant business of distributors. Understanding what adjuvants can or can not do for the active ingredients and products is critical in their marketing. Manufacturers could gain by using adjuvant technology to solve current pesticide performance challenges or assist in post-patent strategies. Support in dealing with industry regulations and cost reductions are paramount.

The industry (agricultural pesticide manufacturers, dealers and growers) expectations of the distributor include integrity, market influence and economic efficiencies. The industry should expect, and in some cases demand, distributor involvement in industry challenges including regulatory issues or market shifts.

PESTICIDE COMPANY PERSPECTIVE. Mark A. Wrucke, Regional Technical Manager, Bayer CropScience, Research Triangle Park, NC 27709.

Adjuvants and adjuvant systems can greatly impact herbicide performance and crop response of many active ingredients. Extensive research efforts are required to determine if an adjuvant is required for maximum performance and to define which adjuvants provide the greatest benefit under various conditions. When developing a commercial formulation, the decision must be made whether to include the adjuvant system in the formulation or to rely on an external adjuvant system. Screening of external adjuvants can be a time consuming and costly process. Experience has proven that not all products in an adjuvant class perform equally. Another observation is that adjuvants can change from one year to the next which may impact performance. Maintaining maximum herbicide performance with active ingredients which require adjuvants demands close cooperation between the herbicide manufacturer and the adjuvant companies. Pesticide manufacturers tend to be reluctant to change adjuvant system and recommendations when they have experience with a system that works well. Ultimate liability for a product’s performance tends to remain with the manufacturer regardless the impact made by an adjuvant system.

CANADA THISTLE PHENOLOGY. Frank Forcella and David Archer. North Central Soil Conservation Research Laboratory, USDA-Agricultural Research Service, Morris, MN 56267.

Natural and experimental populations of Canada thistle (*Cirsium arvense*) were monitored at separate sites in western Minnesota for two and four years, respectively. Both populations responded similarly to environmental cues, except during the establishment year for the experimental population. Otherwise, shoots consistently reached 20, 40, and 60% relative emergence at about 250, 400, and 600 GDD (base temp. = 0 C at 5 cm depth). Thereafter, shoot emergence could not be predicted reliably across sites and years. Heights of the tallest shoots consistently reached half their maximum heights at the summer solstice (21 June), but absolute heights varied annually. Shoot mortality during summer was 25% of the total emerged shoots, and its initial occurrence coincided with flower bud development. Appearance of the first visible flower bud preceded the summer solstice by 10 d, and first anthesis followed 20 d later. Canada thistle phenology is affected by site-specific factors: microclimate, which varies annually; and photoperiod, which does not. Both factors can be used alone and in combination to predict aspects of Canada thistle development.

RESPONSE OF SOYBEAN CYST NEMATODE TO ANNUAL RYEGRASS, PURPLE DEADNETTLE, AND SOYBEAN COMBINATIONS. Valerie A. Mock*, J. Earl Creech, and William G. Johnson, Graduate Research Assistant, Graduate Research Assistant, and Associate Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907-2054.

In the Eastern Corn-Belt soybean cyst nematode (SCN) has become an increasing problem in soybean fields. Annual ryegrass (*Lolium multiflorum*) and SCN-resistant soybeans (*Glycine max*) are non-host species to SCN and are known to reduce the population density. SCN-susceptible soybean and the winter annual weed purple deadnettle (*Lamium purpureum*) are known hosts of SCN. The objective of this greenhouse experiment was to evaluate the influence of mixtures of these plant species on plant growth and SCN population density. This experiment was a factorial arrangement of three plant species, purple deadnettle, annual ryegrass, SCN-susceptible, and SCN resistant soybean. Each plant was present at two levels, one or zero per pot. Seeds were planted into one liter pots and allowed two weeks of growth to establish roots. Each pot was then inoculated with 10,000 SCN eggs, fertilized weekly, and watered when needed. Eight weeks after the experiment was initiated, the above ground dry matter was recorded. Roots were harvested to enumerate SCN cysts and eggs as well as root dry weight. The highest SCN egg and cyst counts occurred on purple deadnettle growing with SCN-susceptible soybean and purple deadnettle alone. The lowest counts occurred with the mixture of SCN-resistant soybean, annual ryegrass, and purple deadnettle. Annual ryegrass and SCN-resistant soybean were successful in reducing SCN population density. Total dry foliage weight was reduced when either soybean variety was combined with purple deadnettle. Dry root weight was highest in pots that contained annual ryegrass and lowest in pots with purple deadnettle alone. In pots that had only purple deadnettle or SCN-susceptible soybean, the purple deadnettle had the highest SCN per gram root dry weight. Purple deadnettle had a SCN egg density per gram of root dry of 170 eggs per gram of root, and the SCN-susceptible soybean had 42 eggs per gram of root.

CONTROL OF WINTER ANNUAL WEEDS AFFECTS SUMMER ANNUAL WEED GROWTH AND MANAGEMENT. Jared S. Webb, Bryan G. Young, William G. Johnson, and J. Earl Creech, Graduate Research Assistant and Associate Professor, Southern Illinois University, Carbondale, IL 62901, Associate Professor and Graduate Research Assistant, Purdue University, West Lafayette, IN 47907.

Removal of winter annual weeds in the fall or early spring may result in earlier planting dates and more consistent control of weed species that sometimes survive burndown applications if delayed until later in the spring. However, in some instances winter annual weed removal has been shown to increase the number of herbicide applications needed in the growing season to control species with extended germination periods such as giant ragweed and common waterhemp. Research was conducted in Illinois and Indiana during the 2005 and 2006 growing seasons to determine what effect winter annual weed removal timing has on giant ragweed and common waterhemp weed growth and management in soybean. Treatments consisted of four winter annual removal strategies: 1) no control of winter annuals in the fall or spring, 2) control of winter annuals in the fall and spring, 3) control of winter annuals in the fall but not the spring, and 4) control of winter annuals in the spring but not the fall. Winter annual weeds were removed with glyphosate applied at 840g ae/ha.

There were no differences in giant ragweed density at initial emergence. From one week after initial giant ragweed emergence until planting the fall only removal strategy generally resulted in a greater density of giant ragweed, compared with other removal strategies. Biomass of giant ragweed at planting in the fall only removal strategy was four times greater than any other removal strategy. The increased biomass of giant ragweed in the fall only removal strategy can be attributed to the increased density and a more advanced plant growth stage. Control of giant ragweed was lowest in the fall only removal strategy at 14, 28, and 56 days after planting. Emergence of common waterhemp occurred earlier in the fall and spring removal strategy and the overall density was generally greater following this removal strategy. Biomass of common waterhemp at planting was greatest in the fall and spring removal strategy and least when winter annual weeds were not removed. Minimal differences were observed for control of common waterhemp after planting. Soybean yield was not affected by removal strategy. Growers interested in earlier removal of winter annual weeds should consider the implications for emergence and control of certain summer annual weed species.

TRANSMISSION OF GLYPHOSATE RESISTANCE IN COMMON RAGWEED. Johnathan P. Dierking and Reid J. Smeda, Graduate Student and Associate Professor, Division of Plant Sciences, University of Missouri-Columbia, Columbia, MO 65211.

In Missouri, glyphosate-resistant (Gly-R) common ragweed has been identified in one 52 hectare area which has been under continuous production of glyphosate-resistant soybeans since their introduction in 1996. Common ragweed seed can be spread to adjacent areas by animals or equipment, but there is concern that transmission of resistance to glyphosate may be mediated by pollen. The objective of this research was to determine the distance that resistance could be spread via pollen from known resistant plants, and the frequency of this event. Along the edge of the area containing Gly-R plants, Gly-R seedlings were established as pollen source plants in a staggered row. Glyphosate-susceptible (Gly-S) seedlings were established in groups of 2-3 plants for replicated, equidistant groups at a distance of 1, 3, 11, 30, 91, 198, and 580 meters from Gly-R seedlings. All Gly-S seedlings were grown in a field containing glyphosate-resistant soybeans. As common ragweed plants matured, pollen from Gly-R plants was permitted to flow across the area containing Gly-S plants. Mature seed from Gly-S and Gly-R common ragweed were collected and planted in a professional potting mix under greenhouse conditions. As seedlings reached 7 to 13 cm in height, they were treated with 1.68 kg ae/ha glyphosate, and evaluated visually 3 weeks later for injury [0-30% (R), 31-89% (I), 90-100% (S)]. For known resistant plants, the frequency of Gly-R plants was 17.5%. Seedlings of Gly-S plants with a Gly-R phenotype were detected up to 91 meters from Gly-R source plants. The frequency of Gly-R plants from the Gly-S population was 1.5, 1.3, 0, 2.4 and 6.4% for the 1, 3, 11, 30, and 91 meter distances from Gly-R source plants. A minimum of 530 total seedlings was examined for Gly-S plants at each distance from Gly-R source plants.

MANAGEMENT OF PROBLEMATIC POPULATIONS OF COMMON LAMBSQUARTERS IN GLYPHOSATE-RESISTANT SOYBEAN. Andrew M. Westhoven*, William G. Johnson, Mark M. Loux, and Jeff M. Stachler, Graduate Research Assistant, Associate Professor, Department of Botany and Plant Pathology Purdue University, West Lafayette, IN 47907, Professor, Extension Program Specialist, Department of Horticulture and Crop Science The Ohio State University, Columbus, OH 43210.

Common lambsquarters (CLQ) biotypes with reduced sensitivity to glyphosate were identified in greenhouse research at Purdue and Ohio State Universities in 2005. Field studies were conducted at four sites in Indiana and Ohio in 2006 to evaluate various control strategies in glyphosate-resistant soybeans. Three different management systems were evaluated consisting of no burndown, burndown without a residual, and burndown plus a residual with various postemergence treatments and timings within each management system.

Both burndown systems effectively controlled all emerged CLQ at the time of application. The burndown plus residual system reduced the number of CLQ at the time of postemergence applications by 71 to 100%. The most effective management strategies, providing the greatest control of CLQ, were 1) a burndown plus a residual and at least one postemergence application of glyphosate, 2) a burndown without residual followed by two postemergence applications of glyphosate, or 3) a burndown without a residual followed by a non-glyphosate postemergence herbicide followed by a postemergence application of glyphosate. Poor control of CLQ occurred when a burndown was not used and only a single postemergence application of glyphosate of 0.84 lb ae/ac was applied. Finally, we observed individual plants that survived multiple glyphosate applications and rates ranging from 0.84 to 3.4 lb ae/ac.

CORN YIELD LOSS PARTITIONED AMONG WATER, NITROGEN, AND PALMER AMARANTH STRESSES. Ella K. Ruf and J. Anita Dille, Graduate Student and Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Corn yield loss can be attributed to many factors such as water stress, nitrogen stress, and weed pressure. Field experiments were conducted near Manhattan, KS during 2005 and 2006 to evaluate the growth and production of corn grown at three nitrogen (N) levels and Palmer amaranth (PA) when grown alone and in competition with each other in two moisture environments. The objective was to determine the influence of increasing PA density on corn yield in furrow irrigated versus dryland conditions, and with varying nitrogen rates of 0, 112, and 224 kg ha^{-1}. In both years, DKC 60-19 RR corn was planted at a seeding rate of 76,600 seeds ha^{-1} and PA was over seeded into each plot as appropriate. Plots were hand thinned to desired PA densities of 0, 1, 4, and 8 plants m^{-1} row corn. Corn ears were hand harvested on 10-8-05 and 10-4-06 from a 4-row meter harvest area located in the center 2 rows of each plot. Ears were then shelled and grain weight, test weight, and moisture were recorded, and yield was adjusted to 15.5% moisture. Corn yield as a function of N rate and PA density were found to have significant interactions with the moisture environment in each year. Corn yields in 2005 ranged from an average 15,435 kg ha^{-1} in the high N rate, weed free, irrigated environment to an average of 3,714 kg ha^{-1} in the low N rate, dryland, high PA density environment. In 2006, yields ranged from an average 16,108 kg ha^{-1} for the high N rate, weed free, irrigated environment to an average of 762 kg ha^{-1} at the low N rate, dryland, high PA density environment with two of the four plots having no yield. Corn grain from 2005 was analyzed using ^{13}C discrimination by Dr. Sharon Clay from South Dakota State University and this analysis allowed for partitioning of the water and N stresses. Analysis revealed that even under the high N rate (224 kg ha^{-1}) significant water stress occurred in the dryland environment whereas in the irrigated environment, minimal N stress was observed. This is consistent with other work published by Dr. Clay. Corn grain from 2006 will also be sent to Dr. Clay for the same analysis. In Kansas, water stress clearly dictated corn yield potential, followed by the presence of PA causing more impact on corn yield than that of available N.

EMERGENCE, SURVIVORSHIP, AND SEED PRODUCTION OF GLYPHOSATE-RESISTANT HORSEWEED IN NO-TILL SYSTEMS. Vince M. Davis and William G. Johnson, Research Associate and Associate Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Horseweed (*Conyza canadensis*) biotypes resistant to glyphosate are commonly found in no-till fields in the eastern cornbelt. Horseweed has generally been considered a winter annual weed species, but tactics to control it solely as a winter annual weed routinely fail. Furthermore, grower surveys from southeast Indiana in 2003 indicated many soybean producers considered horseweed a problematic summer annual and winter annual species. The objective of this study was to determine emergence timing, plant survivorship, and seed production capabilities of a GR horseweed biotype in the presence and absence of other winter annual weeds and/or soybean. A field study was conducted from October 2003 to October 2004 and repeated in an adjacent field from October 2004 to October 2005 in fields following no-till soybean production. Both fields had moderate infestations (approximately 1 plant m^{-2}) of GR horseweed escapes protruding through the soybean canopy at crop harvest prior to trial initiation. Winter survival of plants that emerged in the fall of 2004 was 20% by late April 2005 and was inversely related to rosette size in the fall. Horseweed densities were the highest in mid May of both years and over 90% of the plants at this time emerged in the spring. Plant survival from mid May to mid October was 3% and 21% in 2004 and 2005, respectively. Horseweed plants which protruded above the soybean canopy by early August had greater late season survivorship and produced more seed than horseweed plants below the crop canopy. Average seed production of horseweed which protruded above the canopy was 27,200 and 58,320 seeds $plant^{-1}$ in 2004 and 2005, respectively. Our research indicates horseweed can behave primarily as a summer annual weed in this region and produce significant amounts of seed when uncontrolled in soybean production.

ROLE OF SWEET CORN CANOPY ARCHITECTURE IN CROP-WEED INTERACTIONS.

Yim F. So* (1), Martin M. Williams II (2), Jerald. K. Pataky (1), and Adam Davis (2), Univ. of Illinois, Urbana, IL 61801 (1), Invasive Weed Management Unit, USDA-ARS, Urbana, IL 61801. (2).

Sweet corn canopy architecture influences crop tolerance (CT) to weed interference and weed suppressive ability (WSA) of the crop based on effect on weed growth and fecundity. A quantitative analysis of specific traits responsible for CT and WSA could enhance the impact of hybrid characteristics on weed management in sweet corn. Twenty three sweet corn hybrids from nine seed companies were grown in the presence and absence of wild proso millet in Urbana, Illinois in 2006. Inclusion of hybrids was based on *a priori* qualitative observations of variation in canopy architecture and stress tolerance. Several canopy morphological and phenological traits were characterized from crop emergence to harvest. Crop tolerance to weed interference was determined as weedy ear mass or ear number as a percentage of weed-free yield. At the time of crop harvest, WSA was determined from wild proso millet biomass and fecundity as the inverse of the weed response within a hybrid as compared to a weedy monoculture response. Significant variation among hybrids was observed for most CT, WSA, and canopy traits. Positive correlations ranging from 0.22 to 0.34 ($P < 0.05$) were observed between CT and WSA traits, indicating that there was a slight positive relationship between CT and WSA among these 23 hybrids. Sixteen of the 17 canopy traits were significantly correlated with CT and WSA. Several traits that describe late-season canopy were positively associated with CT traits, including late-season height (0.38 to 0.44), late-season light interception (0.27 to 0.37), leaf area near anthesis (0.28 to 0.42), shoot biomass near anthesis (0.36 to 0.48), and maturity (0.32 to 0.54). Several traits that characterize early canopy development were positively associated with WSA traits, including seedling vigor (0.24), upright leaf angle (0.22), early-season light interception (0.25), and early-season LAI (0.23). Differences in CT and WSA among the hybrids and their significant correlations to canopy growth and development lead us to hypothesize that certain crop traits could be used as indicators of CT and WSA among hybrids. Traits that are associated with late-season canopy morphology appear to provide information on CT, while traits that are associated with early canopy development are useful for describing WSA. Based on these results, we hypothesize that both early development of the crop canopy and final canopy architecture affect crop-weed interactions.

MODELING WEED EMERGENCE. Krishona Martinson, Beverly Durgan, Jochum Wiersma, and Frank Forcella. Assistant Extension Professor, Professor, Assistant Extension Professor, and Research Agronomist. University of Minnesota, St. Paul, MN 55108 and USDA-ARS, Morris, MN 56267.

Wild oat is an economically important annual weed throughout small grain producing regions of the United States and Canada. Timely and more accurate control of wild oat may be developed if there is a better understanding of wild oat emergence patterns. The objectives of this research were to evaluate the emergence pattern of wild oat, and determine if emergence can be predicted using soil growing degree days (GDD) and/or hydrothermal time (HTT). Research plots were established in the Red River Valley of Minnesota and North Dakota from 2002 to 2006. On a weekly basis, naturally emerging wild oat plants were counted and removed from six 0.37 m^2 permanent quadrats randomly distributed in a wild oat infested area. This process was repeated until no additional emergence was observed. Base soil temperature and soil water potential were determined to be 1 C and -0.6 MPa, respectively. Wild oat emergence was significantly correlated with GDD and HTT but not calendar days. A Weibull function was fitted to cumulative wild oat emergence and GDD and HTT. The GDD and HTT models closely fit observed wild oat emergence patterns. The later model is the first to use HTT to predict wild oat emergence under field conditions. These models will aid in the future study of wild oat emergence and assist growers and agricultural professionals with planning timely and more accurate wild oat control.

RESPONSE OF TWO COMMON LAMBSQUARTERS BIOTYPES TO GLYPHOSATE. Andrew R. Kniss, Stephen D. Miller, Robert G. Wilson, and Philip H. Westra, Assistant Research Scientist and Professor, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071, Professor, Department of Agronomy and Horticulture, University of Nebraska, Scottsbluff, NE 69361, and Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523-1177.

Repeated exposure of a weed population to nearly any herbicide increases the potential for resistance, but also for development of increased tolerances and/or escape mechanisms. Common lambsquarters has been noted recently as having the ability to survive in glyphosate-resistant cropping systems to produce seed either by avoidance mechanisms or a low-level tolerance to the glyphosate. Control of lambsquarters with glyphosate has been variable, and previous researchers have concluded that inconsistent common lambsquarters control was more a function of poor management decisions and unfavorable weather rather than differential levels of tolerance within a population. Field studies conducted in Wyoming have confirmed that common lambsquarters biotypes can indeed respond differently to glyphosate applications. Under field conditions, two extreme biotypes differed in mortality by 60% when treated with 840 g ae glyphosate ha^{-1}. This difference between biotypes was confirmed in greenhouse dose-response studies where a three-fold difference in susceptibility was observed with respect to LD_{50} values. Results of ^{14}C-glyphosate translocation studies were inconsistent, and therefore differential translocation between biotypes is likely not the mechanism responsible for the observed differences in whole-plant response.

GLYPHOSATE-RESISTANT HORSEWEED SEEDBANK FLUCTUATIONS UNDER VARIOUS NO-TILL WEED MANAGEMENT SYSTEMS. Greg R. Kruger, Vince M. Davis, and William G. Johnson, Graduate Student, Research Associate, and Associate Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Glyphosate resistance in horseweed is becoming more prevalent in the eastern cornbelt. The biological implications of horseweed populations containing both glyphosate resistant (GR), and glyphosate susceptible (GS) biotypes are unknown. This lack of knowledge makes the development of integrated weed management (IWM) strategies aimed at reducing the presence of GR biotypes in the local weed flora more difficult. The objective of this study was to determine the annual and sub-annual persistence of viable horseweed seed in the soil seedbank in a mixed GR and GS horseweed population under various management systems. A split-plot field study was established in a no-tillage field with crop rotation (soybean-corn or soybean-soybean) as the main plots and management systems as sub plots. In 2003, the study was established in a field that contained a moderate infestation of GR horseweed (approximately 1 plant m^{-2}). The management systems were evaluated by monitoring in-field seed producing adult horseweed densities and sub-annual viable seedbank densities. Seedbank densities were determined from soil samples collected in the spring prior to germination, summer prior to seed rain, and fall following seed rain. Crop rotation did not influence plant or seedbank density. Viable horseweed seed declined rapidly in the soil with an average of 76% for all treatments in the first ten months prior to new seedrain. While persistence of total horseweed seedbank densities seemed minimal, persistence of GR biotypes was similar to GS biotypes. Therefore, to reduce the presence of GR horseweed biotypes in a local no-tillage weed flora, IWM strategies should be developed to reduce total horseweed populations based on the knowledge that seed for GR biotypes no less persistent than GS biotypes.

QUALITY VERSES QUANTITY: SPRING WHEAT SEED SIZE AND SEEDING RATE EFFECTS ON WILD OAT INTERFERENCE AND ECONOMIC RETURNS. Robert N. Stougaard and Qingwu Xue, Professor and Research Associate, Montana State University, Northwestern Agricultural Research Center, 4570 MT 35, Kalispell, MT 59901.

A three-year field experiment was conducted at Kalispell, MT to investigate the effects of spring wheat seed size and seeding rate on wheat yield loss and economic returns as a function of wild oat density. Treatments consisted of four wild oat densities (0, 85, 170 and 340 plants m^{-2}), three spring wheat seed size classes (large, small and bulk), and two spring wheat seeding rates (175 and 280 plants m^{-2}) arranged in a complete factorial design. Weed-free yield potential varied yearly. As yield potential declined, wild oat competitive effects were less evident, and economic thresholds increased. Nonetheless, crop competitive ability increased as wheat seeding rate and seed size increased, with the greatest differences among treatment factors being observed at low weed densities. Both treatment factors decreased spring wheat yield loss, increasing economic returns during all three years of the study despite the higher associated seed costs. Averaged over all other factors, adjusted gross returns were 477 and 537 \$ ha^{-1} for the low and high seeding rates, while values of 453, 521 and 547 \$ ha^{-1} were obtained for the small, bulk and large seed size classes, respectively. Both treatment factors increased economic thresholds in two of three years. These results demonstrate that the use of higher seeding rates and larger seed size classes both improve wheat competitive ability toward wild oat. However, the extent to which economic threshold values are raised will vary depending on the weed-free yield potential.

THE IMPACT OF VARIABILITY IN CROP PLANT SPACING ON POTENTIAL WEED POPULATION GROWTH RATES. Edward C Luschei, Department of Agronomy, University of Wisconsin – Madison, 1575 Linden Drive, Madison WI, 53706.

Weeds escaping overt control at the seedling stage will likely grow and produce seeds in a manner constrained by resource availability in their local neighborhood. Variability in the constraints imposed on growth potential are largely created by the regularity of crop plant spacing and uniformity of emergence timing. In a three year experiment following introduced velvetleaf and shattercane populations within a continuous no-till corn system, mortality rates under conventional control were sufficiently high to lead to near total suppression of the populations. A neighborhood model describing weed response to its local environment revealed a strong connection between gaps and gap size within the matrix of corn plants and potential population growth rate of the weeds. A spatial model derived from the experiment is used demonstrate the importance of spatial regularity within several different demographic scenarios.

THE WEED CONTROL VALUE OF LATERAL ROOT SEGMENTATION IN CANADA THISTLE (CIRSIUM ARVENSE). Richard L. Crow and Edward C. Luschei, Research Assistant, Department of Agronomy, University of Wisconsin, Madison, WI 53706 and Professor, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

Canada thistle is a perennial weed capable of clonal spread from root buds, making this weed especially hard to control. Management of this noxious pest involves a ‘war of attrition’ against stored reserves, in which the importance of clonal interconnectedness is not well understood. In order to investigate the impact of altering clonal connectedness, we randomly applied four treatments to Canada thistle plants growing in52 x 26 x 6 cm flats in a greenhouse. The treatments were: a check, removal of top growth, severing the roots across the center of the flat (narrow way), and a combination of removal of top and severing the roots across the center of the flat. We found that mechanically severing of the lateral roots of a Canada thistle genet resulted in a 57% increase in the number of shoots per unit area, which were thinner and shorter compared to untreated flats (p-value 0.02). The severing of lateral roots seemed to have three important effects on the behavior of the genet: 1. A loss of communication between parts of the clone resulted in an increase in the number of shoots per genet, 2. A reduction in stored root carbohydrate levels per growing shoot, 3. A drop in the average vigor of emerging shoots. The increased number of weaker shoots and increased commitment of storage carbohydrate to regrowth demonstrate the potential of mechanical manipulation of Canada thistle roots as a tactic in low-disturbance attrition-type strategies for control. Investigation on the impact of the strategy in field populations is ongoing.

CAN SOIL BECOME BIOLOGICALLY SUPPRESSIVE TO VELVETLEAF? Jane Okalebo, John Lindquist, Rhae Drijber and Gary Yuen, Graduate Student, Associate Professor, and Associate Professor, Department of Agronomy and Horticulture, University of Nebraska, Lincoln NE 68583-0817 and Professor, Department of Plant Pathology, University of Nebraska, Lincoln NE 68583-0722.

Weed-suppressive soils consist of naturally occurring microorganisms that biologically suppress a weed by inhibiting its growth and development. Increased knowledge of soil-pathogen-weed interactions can assist weed scientists in identifying management practices that improve and enhance suppressiveness of soils, thereby promoting sustainable agroecosystems. Velvetleaf death and growth suppression was observed in a field (*A*) at the University of Nebraska Agricultural Research and Development Center (ARDC). Soils from five fields (including *soilA*) were collected from the ARDC and greenhouse studies were conducted to determine if these soils were biologically suppressive to velvetleaf. Surface-sterilized velvetleaf seeds were sown in pots containing the five soils and emerging seedlings thinned to a constant density. Following eight weeks of growth, velvetleaf mortality was greatest (89%) and biomass was smallest (0.4 g plant^{-1}) in *soilA* compared to the other soils. In a preliminary experiment conducted to further test the biological suppressiveness of *soilA*, pots filled with *soilA* were either sterilized or not. Velvetleaf plants grown for 8 weeks in sterilized *soilA* yielded a total biomass of 4.87 compared to 0.3 g pot^{-1} for the unsterilized soil. The high mortality and reduced growth observed in these experiments was attributed to soil pathogenic fungal species. Results of this research indicate that a soil pathogen may negatively influence velvetleaf population biology. Further research is needed to isolate and identify the species and verify their pathogenic effects on velvetleaf and its associated crop species.

STIMULATION OF GERMINATION OF EASTERN BLACK NIGHTSHADE, SMOOTH GROUNDCHERRY AND CLAMMY GROUNDCHERRY SEEDS WITH SULFONYLUREA HERBICIDES. Robert E. Uhlig and Bernard H. Zandstra, Research Assistant and Professor, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325.

Greenhouse and laboratory studies were conducted to evaluate germination response of eastern black nightshade (*Solanum ptycanthum*) [EBN], smooth groundcherry (*Physalis subglabrata*) [SG], and clammy groundcherry (*Physalis heterophylla*) [CG] seeds to halosulfuron, trifloxysulfuron, rimsulfuron, metolachlor and metribuzin. Weed fruits were collected from different fields in Michigan in 2002. Seeds were extracted from the fruit and stored at -20 C for 2 months and maintained at 5 C until planting. Prior to planting, EBN seeds were treated with hypochlorite (1% v/v) for 8 min. and then rinsed with water for 24 h. In the greenhouse studies, fifty seeds of EBN, SG, and CG were planted in a 4 inch container filled with loamy sand soil. Halosulfuron (0.05 and 0.1 kg/ha), trifloxyuslfuron (0.005 and 0.01 kg/ha), rimsulfuron (0.035 and 0.07 kg/ha) and metribuzin (0.28 kg/ha) were sprayed one day after planting in a spray chamber at 172 kPa with an output of 187 L/ha. Eastern black nightshade percent germination was calculated ((# of plants per pot / # of seed planted)*100) at 5, 14, and 28 days after treatment (DAT); then plants were clipped at the soil surface, dried and weighed. SG and CG plants were counted, at 7, 14, and 40 DAT; then plants were cut, dried and weighed. Trifloxysulfuron at 0.005 and 0.01 kg/ha, and rimsulfuron at 0.07 kg/ha had higher EBN germination rates than control at 14 DAT; however they were not different at 28 DAT. All treatments resulted in lower EBN dry weight, except halosulfuron (0.05 kg/ha) and trifloxysulfuron (0.005 kg/ha) which were not different from the control. SG germination was not affected by any of the sulfonylurea herbicides at 14 DAT, but rimsulfuron [0.07 kg/ha] treated seeds had higher germination (67%) at 40 DAT compared to the control (46%). Results for CG differed between trials. In the first trial, trifloxysulfuron at 0.01 kg/ha had the highest germination at 14 and 40 DAT. In the second trial, none of the treated seeds differed from the control, except trifloxysulfuron (0.21 kg/ha) which had the lowest percent germination.

In the laboratory, EBN seeds were treated with halosulfuron, trifloxysulfuron, rimsulfuron, and metolachlor and SG seeds were treated with rimsulfuron and metolachlor and grown in petri dishes at 30 C. Laboratory results were variable. In the first trial, halosulfuron had the highest EBN seed germination at 3 and 5 DAT. No differences were observed in the second trial, whereas, the third trial control had higher germination than halosulfuron. Trifloxysulfuron [0.005, 0.01, and 0.02 kg/ha] treated EBN seeds were not different from the control and EBN seeds treated with rimsulfuron [0.03 and 0.14 kg/ha] had higher germination in one trial at 15 DAT. Similar to the greenhouse results, SG seed germination was greater with seeds sprayed with rimsulfuron at 0.03 kg/ha at 25 DAT.

These studies suggest that some of the sulfonylurea herbicides could influence SG and EBN seed germination. The germination response to these herbicides, especially halosulfuron, changed over time suggesting other factors are involved. Further studies are needed on temperature and light effects on sulfonylurea herbicide treated weed seeds.

MANAGEMENT OF CANADA THISTLE IN ORGANIC CROPPING SYSTEMS USING SUMMER ANNUAL COVER CROPS AND MOWING. Abram Bicksler and John Masiunas, Graduate Research Assistant and Associate Professor, Department of Natural Resources and Environmental Sciences, University of Illinois, 1201 West Gregory Drive, Urbana, IL 61801.

Canada thistle (*Cirsium arvense*) is a severe problem on Midwestern US organic farms. Cover crops may be a component for suppressing Canada thistle through competition for resources and release of allelochemicals. Canada thistle root carbohydrate reserves are lowest between late June and late August. We hypothesize that Sudangrass or buckwheat cover crops with active growth during this period would be especially suppressive of Canada thistle. Sudangrass is a C_4 species, rapidly closing canopy, reaching heights of 3 m, and producing an extensive root system, which captures moisture and nutrients near the soil surface. Sudangrass contains the allelochemicals sorgoleone and dhurrinase. Buckwheat grows best in early or late summer. It rapidly grows a dense stand that outcompetes Canada thistle. Buckwheat produces allelochemicals although research suggests they do not play a role in Canada thistle suppression. We evaluated buckwheat and Sudangrass alone or combined with mowing for their suppression of Canada thistle. Canada thistle plant densities decreased by 31% in the no cover crop, no mowing treatment. Mowing alone further reduced thistle density and shoot biomass. Buckwheat was very competitive with Canada thistle reducing the number of shoots by 92% and their shoot weight to 21% of the fallow. Mowing reduced the effectiveness of buckwheat in lowering the thistle density probably because buckwheat did not regrow after mowing. Sudangrass without mowing reduced number of thistle plants by 98% but adding mowing provided a further reduction in thistle shoot weights. Sudangrass provides an option for organic farmers to suppress Canada thistle but complete control of Canada thistle will require a multiyear program integrating a variety of management strategies followed by continual monitoring to prevent the establishment of new populations.

CANADA THISTLE SEED DISPERSAL. Ryan P. Miller, Roger L. Becker, Liz A. B. Stahl, Milton J. Haar, Lee D. Klossner, and Frank Forcella, Assistant Extension Professor, Albert Lea Regional Center, Albert Lea, MN 56007-4001, Professor, Department of Agronomy and Plant Genetics, St. Paul, MN 55108-6026, Assistant Extension Professor, Worthington Regional Center, Worthington, MN 56187-2801, Assistant Professor, Department of Agronomy and Plant Genetics, Lamberton, MN 56152, Research Fellow, Southwest Research and Outreach Center, Lamberton, MN 56152, Research Agronomist, USDA-ARS, Morris, MN 56267-1065.

Canada thistle weed laws and enforcement are based upon the premise that Canada thistle spreads by wind-distributed seed. It is not clear to what extent this premise is valid. The objective of this research was to characterize the potential for Canada thistle to spread by wind dispersal. In 2006 studies were conducted at Rosemount, Lamberton, Elysian, St. Paul, Welcome and Morris, Minnesota. Seed traps constructed of wire mesh coated with adhesive were arranged at different distances and heights around a 3-foot diameter patch of Canada thistle. Collection took place over one week during the peak time of dispersal at six locations around MN and measured seed rain and flight. The contribution of wind dispersal to the spread of Canada thistle appears to be largely local. Estimates of seed rain within a twenty-foot radius of the Canada thistle patch was around 3,000 seeds with a relatively small number of seed traveled a distance of 20 feet. More than 90% of pappi were not associated with a viable seed. Dispersal was directional along prevailing winds and pappi with viable seed attached tended to travel closer to the ground than pappi with seeds. Although the amount of seed distributed over long distances appears to be few, it may be an important strategy for discovering new sites. Control efforts timed to prevent the production of viable seed should reduce the spread of Canada thistle.

OVERVIEW OF FEDERAL PROGRAMS AND LEGISLATION AFFECTING INVASIVE PLANTS. Lee R Van Wychen, Director of Science Policy, National and Regional Weed Science Societies, Washington, DC 20002.

The North Central Weed Science Society (NCWSS) needs to continually be proactive on local, state and national invasive plant issues. The election results from November 7, 2006 will impact invasive plant policy over the next two years and beyond as there will be an anticipated shift towards environmental priorities and conservation program spending. NCWSS members can play an important role in advancing invasive plant research priorities through a consolidated constituent voice to their elected officials as well as working with state and federal agencies.

This presentation will provide an update to Federal weed and invasive plant management related legislation and appropriations passed by the 109th Congress. In particular, this presentation will cover the initiatives described in the Salt Cedar and Russian Olive Control Demonstration Act (Public Law 109-320) that was passed by Congress and signed by the President on October 11, 2006 and the Natural Resource Protection Cooperative Agreement Act, which was passed by the Senate on September 29, 2006.

This presentation will also provide analysis of potential new legislation and policy leaders in the upcoming 110th Congress. The NCWSS members will be well represented on key Congressional committees such as Agriculture, Environment/Resources, and Appropriations. This includes the Chairman of both the House and Senate Agriculture Committees and Senate Agriculture Appropriations Subcommittee. One legislative vehicle where NCWSS members can have an impact will be the 2007 Farm Bill which is now expected to move forward in the new year.

INVASION, DOMINANCE AND SPECIES LOSS IN WISCONSIN FOREST UNDERSTORIES

David A. Rogers, University of Wisconsin, Madison, WI.

Species invasions are simultaneously a critical force in maintaining native species diversity, yet also a major conservation threat when the invading species is not native to the system. and thus presents a paradox to resource management. To address this issue, we use a unique fifty-five year old baseline dataset to investigate both native and non-native invasions of Wisconsin forests and they role such invasions play in influencing native understory diversity and composition. We compare original species richness and composition, local environmental variables and surrounding landscape conditions to estimates of native and non-native species invasion for 240 forested stands throughout Wisconsin. For non-native species, initial species richness and landscape measures of human dominance were the best predictors of species invasion. Richer sites in the original survey were less likely to be invaded by exotic species, though this trend was dwarfed by a strong positive correlation with indices of urbanization. For native species invasions, large patches in unfragmented landscapes were more likely to recruit new native species than small patches in highly fragmented or urbanized landscapes. Such invasions were twice as important as extinctions in explaining species losses over the last fifty-five years in Wisconsin forests, supporting the idea that native species invasions are critical to diversity maintenance. Overall, exotic species invasion had no significant correlation with native species losses – perhaps suggesting that, for Wisconsin upland forests, exotic invasion is more a symptom than a cause of declines in native species richness and quality.

ECOLOGICAL CONSEQUENCES OF EXOTIC INVADERS: INTERACTIONS INVOLVING EUROPEAN EARTHWORMS AND NATIVE PLANT COMMUNITIES IN HARDWOOD FORESTS. Cindy Hale, The Natural Resources Research Institute, University of Minnesota Duluth, Duluth MN 55811

European earthworm species have been invading hardwood forest ecosystems in the northern tier of states in the U.S. These hardwood forests have developed since the last glaciation in the absence of native earthworms, and many stands historically had thick forest floor layers, that served as rooting medium for many species of forest herbs and tree seedlings. The exotic earthworms consume the forest floor layer, sometimes leaving exposed mineral soil. Some forest stands have been observed with only one species of native herb and virtually no tree seedlings remaining. Therefore, concerns have been raised about the widespread loss of native forest plant species and the stability of hardwood- forest ecosystems in the western Great Lakes region. The results of three major studies conducted over the last 6 years will be summarized including the dynamics of change across leading edges of earthworm invasion, differential responses or consequences of earthworms among different forest communities, and landscape patterns of earthworm invasions and their impacts. Invasion of hardwood forests by European earthworms is occurring throughout the range of this ecosystem in North America. Local control of invasions into currently worm-free areas may be possible in some situations. However, the magnitude and regional scale of European earthworm invasions that have already occurred suggests that in the next few decades a majority of hardwood forests will be impacted to some degree by earthworms. Research related to the patterns, mechanisms and potential indirect effects of earthworm invasions will be invaluable in directing development of management priorities and strategies.

HARDWOOD FOREST INVASION BY A NON-INDIGENOUS SHRUB (AMUR HONEYSUCKLE) NEGATIVELY AFFECTS OVERSTORY PRODUCTIVITY. Brian C. McCarthy, Professor, Department of Environmental and Plant Biology, Ohio University, Athens, OH 45701-2979.

Despite the fact that hardwood forests throughout the eastern United States are under considerable pressure from invasive species, few studies have explicitly examined whether or not the non-native invader has truly had an impact on the system. Numerous studies in the forestry literature document interference from lower vegetation layers on the overstory. With this in mind, we chose to examine whether or not stand invasion by Amur honeysuckle had an effect on overstory productivity. We chose 16 replicate hardwood stands from southwestern Ohio such that four were uninfected (controls) and twelve had Amur honeysuckle as the dominant component of the understory. All infected stands had noticeably lower species diversity and vegetation cover below the shrubs (a pattern that has been well documented by various investigators), but the impact to the overstory was less clear. A minimum of twelve trees (N = 196) were sampled from each stand via increment coring. Standard dendrochronological protocols were applied, cores were prepared and cross-dated, and then radial growth and basal area increments were calculated for each tree. Within each stand, Amur honeysuckle shrubs were cut and dated to determine maximum age (time of invasion). Intervention analysis was then applied to detect growth changes 25 years prior to and 25 years following invasion. The rate of radial and basal area growth of overstory trees was reduced significantly in eleven out of twelve invaded sites. Non-invaded sites did not exhibit this consistent pattern of reduced growth. For invaded versus non-invaded sites, the mean basal area growth was reduced by 15.8%, and the overall rate of basal area growth was reduced by 53.1%. Intervention analysis revealed that the first significant growth reductions were 6.25 ± 1.24 (mean ± SE) yrs after invasion with the greatest frequency of negative growth changes occurring 20 yrs after invasion. In invaded stands, 41% of trees experienced negative growth changes. In terms of invasive load estimates per 1000 honeysuckle individuals, radial tree growth was reduced by 0.56 $mm \cdot yr^{-1}$, and basal area growth was reduced by 0.74 $cm^2 \cdot yr^{-1}$. Given these findings, significant economic losses could occur in hardwood forests invaded by Amur honeysuckle.

GARLIC MUSTARD: AN UNREMARKABLE ENGLISH WILDFLOWER CONQUERING AMERICA. Steven G. Hallett, Associate Professor, Department of Botany and Plant Pathology, Purdue University, 915 West State Street, West Lafayette, IN 47907.

It has become increasingly apparent that invasive plants can have devastating impacts upon ecosystems, but it is not always clear how their impacts are mediated. For some plants there are intuitive explanations, such as salt cedar (*Tamarisk* spp.) which modifies the hydrology of riparian systems, and cheatgrass (*Bromus tectorum*) which modifies fire regimes. For other plants, however, the process and impacts of invasion are more difficult to explain. In Europe, garlic mustard (*Alliaria petiolata*) is an unremarkable wildflower; common but not weedy. Yet it has invaded North America from the eastern seaboard to the Midwest. The explanation for the garlic mustard invasion seems to lie underground. The relationships among garlic mustard and its associated soil biota in Europe are the result of millennia of coevolution. The relationships among garlic mustard and its associated soil biota in North America are very recent. Thus, the North American soil biota are completely naïve to the biological weapons that garlic mustard has evolved in its perpetual battle against the Europeans. It turns out that garlic mustard has evolved a potent arsenal. Allelochemicals from garlic mustard have only a modest effect on soil microbial communities from Europe, presumably because they have evolved avoidance, tolerance and/or resistance mechanisms. In contrast, the allelochemicals of garlic mustard are devastating to the naïve soil microbial communities of North America. One particularly important group of soil microbes is the arbuscular mycorrhizal fungi (AMF), a group of symbionts from which many plants derive significant nutritional benefit. The negative impact of garlic mustard upon North American AMF may hold the key to understanding the remarkable invasion ecology of this otherwise unremarkable plant.

EMERGENCE AND CONTROL OF POISON HEMLOCK. Carl A. Woodard and Reid J. Smeda, Graduate Research Assistant and Associate Professor, Division of Plant Sciences University of Missouri. Columbia, MO. 65211.

Poison hemlock (*Conium maculatum* L.) is an invasive, biennial plant that has become a significant problem weed in roadside and right of way areas across the central U.S. Poison hemlock is considered noxious in eight states, yet little information is available on the biology, reproduction and control of this plant. Glyphosate, glyphosate plus S-metolachlor, rimsulfuron plus thifensulfuron-methyl, metsulfuron-methyl, sulfometuron-methyl plus metsulfuron-methyl, chlorsulfuron, 2,4-D, 2,4-D plus picloram and dicamba are the herbicides currently labeled for control. The objectives of this research were to determine the emergence patterns of poison hemlock and to identify herbicides that result in optimum post emergence-control. Emergence studies were initiated at three locations in Missouri, with seed placed in five, 1 m^2 plots at each location. Seedling emergence was recorded at bi-monthly to monthly intervals. Across all three locations, mean percent spring emergence was approximately 9% of the total seed sown; 6% occurred in April alone. Mean percent fall emergence was approximately 4.5% of the total seed sown; 3.4% occurred in September alone. The latest date emergence was record was November 1, 2006. No emergence was recorded throughout the summer months. Field studies to evaluate herbicide efficacy were conducted at two locations. Studies at both locations consisted of 14 treatments arranged in an RCB design. Visual control was assessed at 2, 4, 8 and 12 weeks after treatment (WAT). At 4 WAT, no herbicide resulted in >90% visual control, cool conditions slowed herbicidal activity. At both locations 8 WAT, imazapic plus glyphosate, chlorsulfuron, metsulfuron-methyl, and metsulfuron-methyl plus 2,4-D plus dicamba, resulted in >90% visual control. Treatments resulting in <30% visual control at 8 WAT were diflufenzopyr plus dicamba and aminopyralid. Emergence patterns of poison hemlock indicate that spring herbicide applications are needed for initial control and residual control of later-emerging seedlings. This data suggests that the duration between spring and fall emergence precludes application of a single residual herbicide.

TILLAGE AND PLANT GROWTH REGULATOR PRETREATMENTS ENHANCE REED CANARYGRASS CONTROL WITH SETHOXYDIM. Craig A. Annen, Consulting Ecologist, Michler & Brown, LLC, Belleville, WI 53508.

Long-term suppression of reed canarygrass (*Phalaris arundinacea* L.) can be difficult to achieve with herbicides, partly because this species can resurge (resprout) from its rhizomes whenever applications are suspended. A system of apical dominance may operate in reed canarygrass rhizomes, resulting in a persistent rhizome bud bank that must be depleted through repeated herbicide applications in order to achieve effective, long-lasting control of this species. Pretreatments (treatments applied prior to herbicide application) that short-circuit rhizome apical dominance may predispose reed canarygrass to more effective chemical control. Tillage and plant growth regulator (PGR) applications have been shown to short-circuit rhizome apical dominance and enhance chemical control in several invasive perennial grass species. I conducted a three-year experiment to determine if coupling tillage or PGR application to sethoxydim (Vantage®) application would enhance reed canarygrass suppression and reduce its resurgence capacity greater than sethoxydim application only. Compared to the herbicide-only treatment, tillage + sethoxydim treatments enhanced reed canarygrass suppression (up to 443% greater), reduced rhizome resurgence capacity (228% greater), and indirectly led to increases in native species abundance by surfacing the seed bank. Coupling PGR pretreatments to herbicide application reduced reed canarygrass resurgence capacity 26% greater than herbicide application only. Results of this experiment demonstrate that tillage and PGR pretreatments can enhance the effects of sethoxydim herbicide on reed canarygrass.

BIOLOGY AND MANAGEMENT OF CUT-LEAVED TEASEL. Diego J. Bentivegna and Reid J. Smeda, Graduate Research Assistantship and Professor, Division of Plant Science, University of Missouri, Columbia, MO 65211.

Cut-leaved teasel is an exotic and highly invasive weed along roadsides and unmanaged areas. It is a biennial, growing as a rosette in the first year followed by a reproduction stage during the second year. Among the negative effects, teasel reduces diversification of species, decreases traffic visibility and alters soil moisture levels. The objectives were to identify emergence periods, growth aspects, total seed production, and effects of chemical management. Teasel emergence was counted up to one year after placing seeds at two locations. Teasel growth was evaluated over a life cycle on 10 plants at two locations, with the following parameters measured for each plant: aboveground and belowground biomass; total leaf area. Fifteen plants under two levels of intraspecific competition were used to measure the seed production at two locations over two years. Herbicides were spread in naturally infested sites at labeled rates in two locations and for two years, with injury visually estimated up to two months later. Four different modes of action were used: amino acid biosynthesis inhibitors, growth regulators, acetolactate synthase inhibitors, and cell membrane disruptors. Principally, teasel emergence occurred in only two months (April and October), with 32.5 % of sown seed emerged. Teasel exhibited two peaks for above-ground biomass; in September of the first year (rosette leaves); and during June in the second year (leaves, stems, and seedheads). Maximum aboveground and belowground biomass was 392 grams plant^{-1} and 82 g plant^{-1}, respectively. Plants stored resources in the taproot only the first year. Maximum leaf area per plant was 15,050 cm^2 and peaked with the time of optimum biomass production. Single plants produced from 6 to 36 seedheads, with total seed production averaging 12,600 seeds in plants growing alone. In contrast, plants with intraspecific competition reduced seed production to 4,300 seeds plant^{-1}. The principal seedhead produced from 880 to 1,300 seeds. Glyphosate, 2,4-D, 2,4-D + triclopyr, 2,4-D + picloram, 2,4-D + clopyralid, dicamba, imazapyr, metsulfuron-methyl, and paraquat provided optimum control (>90%) of rosette plants. Control with sulfometuron-methyl was only 80%, and control with sulfosulfuron was insufficient (<33%). Application of herbicides at the end of April and October (after seedlings emergence) appears optimal for control of new and established plants.

CONSTRUCTION OF A NON-NATIVE INVASIVE SPECIES DATABASE FOR ELEVEN SOUTHERN ILLINOIS COUNTIES. Jason R. Inczauskis, Molly S. Hacker, Loretta L. Battaglia, and David J. Gibson, Graduate student, Undergraduate student, Assistant professor, and Professor, Department of Plant Biology, Southern Illinois University Carbondale, Carbondale, IL 62901.

Non-native invasive species (NNIS) are a major threat to the ecological function and biodiversity of many native communities. The full distribution of these species is still uncertain, however. The objective of this study was to determine the extent of NNIS in the eleven southernmost counties of Illinois, in terms of the number of invasive species and their distribution. We extracted information from published literature, Illinois Critical Trends Assessment Program (CTAP), informants, and herbaria records from Southern Illinois University Carbondale (SIUC), the Shawnee National Forest, and the Illinois Natural History Survey (INHS), and used this information to construct a database in Microsoft Excel that can be queried for location of occurrence, general habitat, landscape features, and year of documentation. Information from these records was used to determine more specific locations on a map to obtain the most spatially accurate UTM coordinates possible. Each record documented in this way was also assigned a resolution category based on how accurate a location could be obtained from the available data. Most of the records have been placed within several km of their estimated point of origin, based on location data available in each record. Our database currently contains over 8,700 records and over 550 non-native species. This database will give us a greater understanding of non-native species expansion patterns, allowing us to pinpoint NNIS hotspots, and aid in future attempts at NNIS control.

MAPPING THE EXTENT OF INVASIVE PLANT SPECIES ON WISCONSIN STATE FOREST LAND. Sarah K. Herrick, Invasive Plant Survey Coordinator, WDNR, Division of Forestry, Madison, WI 53703.

Invasive plants pose a serious ecological and economic threat to Wisconsin's valuable forest resources. These pests reduce biodiversity by out-competing native species, degrade fish and wildlife habitat, reduce agricultural yields, prevent forest regeneration and may alter important ecological processes like hydrology, nitrogen fixation, and natural fire cycles. During the 2006 field season, the Wisconsin Department of Natural Resources Division of Forestry completed a GIS based inventory of terrestrial invasive plant species within Wisconsin's State Forests. The objective of the survey was to collect information on the ecology of invasive plants within Wisconsin's State Forests, including the location and area of infestations, spread patterns, new and common invaders, and to map the current existence and extent of invasive plant infestations on state forest land. Each State Forest identified a list of priority search areas for invasive plant surveys. Priority areas included corridors along roads and trails, homesteads, boat landings, river ways, timber sales, gravel pits, recreational sites and campgrounds. These areas were surveyed in as close to their entirety as was feasible, and were visited at least twice during the field season to ensure proper identification of plants based on the phenology of the target species. Data collected during the survey will be used to establish a baseline database to aid in the development of invasive plant management goals and objectives and in measuring the progress of future management programs on state forest land.

APPLICATION TIMING OF 20 BASAL BARK HERBICIDE AND OIL DILUENT COMBINATIONS APPLIED TO TWO SIZES OF AMUR HONEYSUCKLE. Ronald A. Rathfon, Extension Forester, Department of Forestry and Natural Resources, Purdue University, Dubois, IN 47527.

In previous studies and in operational field experience, low volume basal bark herbicide treatments have produced inconsistent control of Amur honeysuckle (*Lonicera maackii* (Rupr.) Herder). Twenty different factorial combinations of herbicides and oil diluents were applied to two different size Amur honeysuckle shrubs (4.5 -8 ft. tall and >8 ft. tall) every other month, beginning in July 2004, for six treatment timing applications over a one year period ending in May 2005. The herbicide treatments were: 20% triclopyr ester (Garlon 4), 1% imazapyr (Stalker), 20% triclopyr + 1% imazapyr, 3% imazapyr, and 15% triclopyr + 3% imazapyr. The oil diluent treatments were: diesel oil, AX-IT (paraffinic petroleum distillate), JLB Plus (vegetable oil + d'limonene emulsifier), and Arborchem (aliphatic and paraffinic petroleum distillate).

All three herbicide treatments containing triclopyr, across all oil diluent, shrub size, and month of application treatments, each controlled 94-95% of treated Amur honeysuckle shrubs after two growing seasons. Less than 1% of treated shrubs in triclopyr-containing herbicide treatments produced basal sprouts after two growing seasons. The 1% imazapyr-alone and 3% imazapyr-alone treatments, across all oil diluent, shrub size, and month of application treatments, controlled only 55% and 69% of treated Amur honeysuckle shrubs, respectively. Twenty-five percent of shrubs treated with 1% imazapyr-alone and 19% of shrubs treated with 3% imazapyr-alone produced basal sprouts after two growing seasons. The type of oil diluent did not influence the overall efficacy of the three triclopyr-containing herbicide treatments. The JLB Plus oil diluent reduced control rates for the 1% imazapyr-alone and 3% imazapyr-alone herbicide treatments to 26% and 51%, respectively. The large size class (> 8 ft. tall) of Amur honeysuckle proved more difficult to control than the smaller size class (4.5 – 8 ft. tall), particularly for the 1% and 3% imazapyr-alone herbicide treatments where control was 19% and 14% less, respectively. The larger shrub class was also more likely to produce basal sprouts with these two herbicide treatments; 31% of >8 ft. shrubs treated with 1% imazapyr-alone produced basal sprouts versus 21% of 4.5-8 ft. shrubs; and 25% of >8 ft. shrubs treated with 3% imazapyr-alone produced basal sprouts versus 13% of 4.5-8 ft. shrubs.

Except for a 76% control rate in the July 2004 application, month of application did not affect the three triclopyr-containing herbicide treatment efficacy rates, which exceeded 95% in all other months. In the July 2004 application, high air temperatures on the date of application and for two days thereafter exceeded 32^{o}C. The ester formulation of triclopyr used in this study is known to volatilize under certain conditions above 28^{o}C. Diesel oil is more volatile than the other oil diluents at this air temperature. Triclopyr diluted in diesel oil and applied to the large size class tended to have much lower rates of control in the July 2004 application, ranging from 13%-63%, thus bringing down the overall mean for the herbicide treatments in that month. Because of these factors, less active ingredient may have been delivered into target shrub vascular systems in July 2004 than in other months. Although the two imazapyr-alone treatments had lower control rates throughout the entire year than the triclopyr-containing treatments, the July 2004 and January 2005 imazapyr-alone treatment applications had significantly lower rates of control than in other months of the year. For the imazapyr-alone herbicide treatments, basal sprouting rates were significantly higher for shrubs treated during the dormant months, November 2004 – March 2005, with the January 2005 treatment application resulting in 49% and 35% of shrubs producing basal sprouts for the 1% and 3% imazapyr-alone herbicide treatments, respectively. Only the May 2005 application of 3% imazapyr-alone provided acceptable levels of control (82%-95% across the four diluents) and basal sprouting (6%-11%).

2006 North Central Weed Science Society Proceedings 61:189.

Triclopyr, when correctly applied as a basal bark treatment, effectively controls Amur honeysuckle. Triclopyr basal bark efficacy remains consistently high when diluted with any one of a variety of oil diluents, when applied at any time of the year except when air temperatures exceed 28^{o}C-30^{o}C, or regardless of shrub size. Manufacturer label directions advising against the use of basal bark treatments when the bark is wet or frozen, or when snow is on the ground, should be followed. When Amur honeysuckle is the primary target of vegetation management efforts, the addition of imazapyr to triclopyr is unnecessary. Imazapyr applied as a basal bark treatment for control of Amur honeysuckle, at the rates investigated in this study, provides inadequate control in most months and regardless of diluent used, or size of target shrub treated.

LONG TERM LEAFY SPURGE MANAGEMENT IN AN OAK SAVANNA SETTING. Jerry D. Doll, Weed Scientist Emeritus, University of Wisconsin, Department of Agronomy, Madison, WI 53706, and J. Kim Mello, Biologist, Wildlife Management Program, Department of Defense, Ft. McCoy, Sparta, WI 54656.

Leafy spurge continues invading new areas in Wisconsin. It provides a particularly difficult management problem in prairie habitats where neither mowing nor managed grazing are normally practiced. One such site is Fort McCoy in Monroe Co. Wisconsin. The oak savanna habitat is found on much of their 60,000 acres and it seems ideally suited for leafy spurge invasions which threaten the warm season grasses and forbs. Herbicide trials were initiated in 1999 and an integrated project that combines insects, mowing and herbicides began in 2003.

The first trial compared fall applied imazapic (Plateau) and spring applied quinclorac (Paramount) in two locations. Imazapic was applied at 0.125 lbae/a. Quinclorac rates were 0.56 lbai/a in 1999 and 2000 and 0.375 in 2001 and beyond to comply with label changes. Diflufenzopyr enhances the activity of several herbicides on leafy spurge. As this molecule is not sold separately, 2 oz/a (commercial product) of a premixture containing 20% diflufenzopyr and 50% dicamba (Distinct) were added to both the imazapic and quinclorac treatments. Recommended additives were used with each product. Replicated plots were 20 by 40 ft in size. Herbicides were applied with a CO2 sprayer fitted with flat fan nozzles. Frequency of application varied and included one, two and three applications in varying patterns (for example, imazapic was applied only in 1999, in 1999 and 2001, or in 1999 and 2002). Spurge populations were determined by counting all live stems 2x2-ft quadrats in five predetermined sites on a diagonal line across each plot each spring and fall.

In September 1999, the plots treated with quinclorac that spring were nearly devoid of leafy spurge. A year later, a noticeable population of leafy spurge plants (63 to 188 stems/100 ft^2) appeared in plots that received quinclorac. The 1999 fall-applied imazapic treatments had spurge populations of 6 to 88 plants/100 ft^2 in the spring of 2000 Most plants seemed to have originated from seed because they were quite small. The site was burned as part of the oak savanna management strategy in 2001. This triggered abundant spurge reinfestation, primarily via seed germination. Thus, all plots with two or more planned applications of quinclorac or imazapic were treated in 2001. Leafy spurge populations in Sept. 2001 following quinclorac applications in the spring were greatly reduced.

In 2002, leafy spurge populations remain very high in the areas that received quinclorac or imazapic only in 1999. Quinclorac applied in 1999 and 2001 had relatively low leafy spurge populations in June, 2002 and a moderate population in September. Quinclorac applied in 1999 and 2002 had a moderate spurge population in the fall, reflecting the reduced spurge control at the 0.375 lb/a rate (as per a label change) and this rate may not give the level of suppression as compared to the 0.56 lb/a rate needed to achieve consistent spurge control.

Imazapic applied in the fall of 1999 and 2001 resulted in no leafy spurge plants in June 2002 and a low population in Sept. The untreated plots show an interesting pattern of higher leafy spurge populations in June than Sept. (avg. of 1080 plants/100ft^2 in the spring and 770 in the fall).

The key observations from this study are that leafy spurge required two or more herbicide applications to maintain populations at acceptable levels over the 5-yr period of this study; applications would be on an every other or every third year frequency; burning allows (promotes?) spurge reinfestations. Therefore, on sites where burning is practiced, burn before applying herbicides; spurge populations vary naturally over the season with highest populations in the late spring and much lower densities noted in the fall. The pattern of spurge populations being higher in June than Sept. was true every year. Averaged over 5 years, the spring population was 1188 plants/100 ft^2 and the fall population was 685 plants/100 ft^2 in the check plots.

The second trial is an integrated management study that started in 2003. It includes insects (*Aphthona* spp.), mowing and imazapic alone and in all combinations for a total of eight treatments.

Sites were located over a wide distance as we needed to select areas where insects had been released and established over a 5- to 10-year period prior to 2003 and other sites where they had never been released. Mowing was done in June when spurge was flowering to minimize seed production and weaken plants. Imazapic was applied in the fall of 2003 (0.156 lbae/a) with recommended additives to areas no less than 2000 ft^2 (average of 3185 ft^2 per plot). Treatments were replicated three times and the herbicide was applied with a lever-activated backpack sprayer fitted with six flat fan nozzles. Imazapic was only applied in subsequent years when the spurge population exceeded 175 plants per 100 ft^2. Spurge populations were monitored in the early summer and fall by counting live stems in four 2x2-ft quadrats in the center region of each plot in a systematized manner. Adult beetles were sampled periodically in May and June with a standard sweep net swept 16 times (four in each ordinate direction) in the center region of selected plots.

Early summer spurge populations ranged from 221 to 535 stems per 100 ft^2 in the non-treated areas and were essentially unchanged from 2003 through 2006. Imazapic alone has reduced populations to an average of less than 22 stems per 100 ft^2. Spurge populations are declining with mowing alone (from 573 per 100 ft^2 in 2003 to 273 per 100 ft^2 in 2006). Insects alone show only a slight drop in spurge populations over the 4 years of the study. Combining imazapic with either mowing or insects was no more effective than imazapic alone. The same is true with the use of insects, mowing and herbicide.

The beetle populations varied from 15 to 50 per 16 sweeps the summer of 2003 before mowing or herbicides were implemented. No beetles were found in the beetle region in 2004 following the imazapic treatment in the fall of 2003. This is logical as spurge populations in the treated areas were near zero, eliminating the host plant for the insect. In 2005, 8 to 18 beetles per 16 sweeps were collected in the herbicide treated regions while 50 to 60 were found in the non-treated areas. A similar beetle population pattern was noted in 2006. Beetle density in the insect only areas increased over time, reaching the maximum beetle population of 84 beetles per 16 sweeps in 2006. However, spurge populations were seldom affected by beetles alone during this time period. Mowing generally reduced beetle populations but also suppressed spurge abundance.

It appears that herbicides provide the fastest and most consistent spurge suppression. To date, we see little advantage to mowing or insects in the battle. However, the study is only in the fourth year and will continue for several years to see if additive or synergistic effects appear. Or we may reach a point where we stop using herbicides to see if insects alone or in combination with mowing can continue suppressing leafy spurge in this oak savanna habitat.

MANAGING INVASIVE PLANT SPECIES IN WETLANDS. Nicole Kalkbrenner, Regional Manager Ecological Services – Wisconsin and Brian Majka, Unit Manager – Michigan, JFNew, 1402 Pankratz St., Suite 302, Madison, WI 53704 and JFNew, 11181 Marwell Ave., West Olive, MI 49460.

Over the past 15 years JFNew has provided invasive species management for our clients and has learned certain successful techniques. We will discuss the practical applications of managing invasive species in wetlands throughout the Midwest, particularly around Lake Michigan. We will identify a handful of the worst invaders in natural wetland systems and highlight methods that have worked to control these invaders. These methods will be described in more detail for each species in which a particular method is used. Chemical, mechanical, biological and hydrological methods will all be discussed as well as combinations that include more than one method.

PURPLE LOOSESTRIFE CONTROL WITH HERBICIDES: MULTI YEAR APPLICATIONS. Stevan Z. Knezevic, Haskell Ag. Lab., University of Nebraska, Concord, NE, 68728-2828**.**

The introduction and spread of exotic plant species is one of the most serious threats to biodiversity. Purple loosestrife (*Lythrum salicaria*) is one such species that is currently invading wetlands and waterways in mid-Western states including an estimated 5,000 hectares in Nebraska. Our 10-year long studies were initiated in 2000 at four locations in NE with the objective to evaluate performance of the multi-year applications of 14 herbicide treatments. Treatments were applied on as needed basis one time per year during purple loosestrife flowering. Evaluations suggested that 3 years of yearly spraying of aquatic glyphosate at 1.8 and 3.36 kg ae/ha provided excellent purple loosestrife control (>90%) for three following years. Two years of spraying imazapyr at 1.12 and 1.68 kg ai/ha and metsulfuron at 0.070 and 0.175kg ai/ha provided excellent purple loosestrife control (>90%) for three following years. The two imazapyr treatments however caused detrimental effects on the native vegetation, especially grassy species, indicating limited use of those treatments. The 2,4-D at 1.4 and 2.8kg ae/ha; and triclopyr at 1.1 and 2.1kg ae/ha were the treatments that needed to be applied every year. Herbicides can be viable tool for loosestrife control as part of the integrated management package. Applying herbicides for two or three continuous years combined with other weed control methods may prove to be the long term strategy for purple loosestrife control (sknezevic2@unl.edu).

THISTLE CONTROL IN USA RANGELAND AND PASTURES WITH AMINOPYRALID. Byron B. Sleugh, Robert Wilson, Scott Nissen, Stephen Enloe, Robert A. Masters, Vanelle F. Carrithers, and Pat L. Burch. Dow AgroSciences, LLC, West Des Moines, IA 50266; University of Nebraska Panhandle Research and Extension Center, Scottsbluff, NE 69361; Colorado State University, Fort Collins, CO 80523; University of Wyoming, Laramie, WY 82071; Dow AgroSciences, LLC, Indianapolis, IN 46268; Dow AgroSciences, LLC, Mulino, OR 97042; Dow AgroSciences, LLC, Christiansburg, VA 24073, respectively.

Experiments at multiple rangeland and pasture sites across the USA were conducted to determine the response of Canada thistle to aminopyralid, a new herbicide active ingredient introduced by Dow AgroSciences in 2005 for use on rangeland, pastures, and non-cropland. Aminopyralid was applied to Canada thistle plants at varying growth stages including pre-bud and bud in the spring and summer and to autumn regrowth. Efficacy of aminopyralid at 52 to 120 g ae/ha was evaluated during the season of application, one, and two years after application. Aminopyralid treatments were compared to herbicides commonly recommended for Canada thistle control including picloram, dicamba, 2, 4-D, and clopyralid. At 1 year after treatment, aminopyralid applied to Canada thistle in the autumn or spring at 105 g/ha or higher provided excellent control similar to control with picloram at 280 to 360 g/ha and superior to control with dicamba, clopyralid, and 2,4-D. A summary of the results from trials based on Canada thistle growth stage indicated that better control is obtained when aminopyralid is applied at the pre-bud or bud stage. At 2 years after treatment, aminopyralid treatments applied in the fall to Canada thistle regrowth provided 87%, 90%, and 93% control for the 90, 105, and 120 g ae/ha, respectively. It was evident from these data that the best long term control for Canada thistle was obtained by fall applications of aminopyralid. In these experiments, introduced cool-season forage grasses (smooth bromegrass, timothy, orchardgrass, tall fescue, and Kentucky bluegrass) and native perennial grasses (prairie junegrass, big bluestem, little bluestem, and sideoats grama) were not injured by aminopyralid, regardless of rate applied.

TEBUTHIURON: A TOOL FOR TALLGRASS PRAIRIE RESTORATION. Robert A. Masters, Rangeland Scientist, Byron B. Sleugh, Forage Agronomist, Dow AgroSciences LLC, IN 46268, Walter H. Schacht, Rangeland Scientist, and Christopher Kopp, Research Technician, University of Nebraska, Lincoln, NE 68583

Tallgrass prairies once extended over 240 million acres in North America, stretching from Texas into the prairie provinces of Canada. Today, tallgrass prairies are among the most reduced grassland community types in North America. A variety of factors have contributed to their demise including conversion to cropland, management that has promoted invasive by exotic plant species, and urbanization. There are situations in the central and northern Great Plains grasslands where plant species composition has shifted such that introduced cool-season grasses have come to dominate because of management practices that have facilitated the invasion, establishment, and expansion of these exotic grasses. Experiments were conducted to determine if the herbicide, tebuthiuron, could be used to cause a rapid shift in species composition by controlling cool-season grasses and releasing remnant warm-season grasses. Tebuthiuron was applied on degraded grassland sites in southeast Nebraska at rates of 1.1, 2.2, and 3.3 kg active ingredient (ai) ha^{-1} in the autumn in 2003 and 2004. Plant community attributes measured in mid-summer 2004, 2005, and 2006 included yield of warm-season grasses, cool-season grasses, and forbs. Tebuthiuron, regardless of rate applied, suppressed the cool-season grasses (Kentucky bluegrass smooth bromegrass, and cheatgrass). By 260 days after treatment, cool-season grass yields were less than 125 kg ha^{-1} compared to yields of over 700 kg ha^{-1} on areas that were not treated with herbicide. In contrast, yield of warm-season grasses (big bluestem and little bluestem) were greater than 3500 kg ha^{-1} by 260 days after treatment compared to yields of less than 961 kg ha^{-1} on areas that were not treated with herbicide. This relatively rapid increase in warm-season grass yields appeared to be the result of their release from competition with the cool-season grasses controlled by tebuthiuron. Once released from competition with the cool-season grasses the warm-season grasses were able to more fully express their yield potential.

HEDGE PARSLEY: SHARING IDEAS, LOOKING FOR ANSWERS. Anne M. Helsley [1] and Daniel J. Wallace [1,2], [1] Wisconsin Department of Natural Resources Land Stewardship Volunteer and [2] Brooklyn Wildlife Area Segment Manager, Dane County Chapter of the Ice Age Trail

Hedge parsley (*Torilis japonica*) has been known in the Brooklyn State Wildlife Area (southern Dane and northern Green counties, south central Wisconsin) for approximately 4 years, and we have been removing it off and on for about 3 years. This year, as it became a geographically more widespread problem and we have come to understand it better, we have spent considerably more time and effort on its control. This is not an impossible task, but there are serious factors to overcome, including the high mobility potential of the seeds and the plant's ability to thrive in many different environments. Although it appears to prefer moister soils, and it is considered to be a woodland invasive, hedge parsley grows in many different environments, including woods, woodland/prairie boundaries, and open prairies. In order to control the spread of hedge parsley there needs to be a dedicated and comprehensive plan to deal with it. Since hedge parsley is a relatively unknown and new invasive, as land stewards we will first need to educate ourselves concerning the plant's physiology and invasive behavior and also share our knowledge with others. We will present the approaches we have used in the control of this newer invasive and our understanding of the plant, and in this session we will encourage others to share additional ideas.

ASSESSING THE IMPACTS OF BIOLOGICAL CONTROL ON SPOTTED KNAPWEED, *CENTAUREA BIEBERSTEINII* D.C., IN MINNESOTA. Natasha M. Northrop and Anthony B. Cortilet, Research Scientists, Minnesota Department of Agriculture, St. Paul, MN 55155.

Spotted knapweed is an exotic terrestrial plant of Eurasian origin that threatens Minnesota's roadside, rangeland, agricultural, and grassland/prairie ecosystems. Minnesota land owners/managers are searching for less expensive and more environmentally compatible alternatives to herbicide use for management and control of this weed. The United States Department of Agriculture (USDA) released eleven biological control agent species in the state from years 1989 through 2000. Prior to the Minnesota Department of Agriculture (MDA) inheriting the program in 2000, few attempts had been made to assess the establishment and success of agents throughout the state to determine if biological control was a viable pest management strategy for spotted knapweed. This research grant was developed in an attempt to increase our knowledge of spotted knapweed biological control in Minnesota and to evaluate the impacts that bioagents have on this highly invasive weed. Results determined that six of the eleven bioagents released in Minnesota, *Urophora affinis*, *Urophora quadrifasciata*, *Larinus minutus*, *Larinus obtusus*, *Cyphocleonus achates*, and *Agapeta zoegana*, are established, have impacted the growth and spread of spotted knapweed on several sites, and are collectable for redistribution to new infestations in the state. Rigorous sampling of selected biological control sites has provided the MDA with important information pertaining to the extent of spotted knapweed infestations, composition of other vegetation, and various landscape, soil, and geographical parameters characterizing infestation sites in Minnesota. It is not the only option, but biological control can be an important tool for spotted knapweed management in Minnesota. It has the potential to have long-term and sustainable impacts on large infestations where herbicides and other IPM tactics are not practical, are too expensive, or are ecologically unsound. Through this LCMR (Legislative Commission on Minnesota Resources) grant, the MDA has dramatically increased its knowledge of spotted knapweed in the state and the possibilities for extensive biological control management in the future.

FIELD AND COMMON GARDEN ECOLOGICAL AND MORPHOLOGICAL CHARACTER COMPARISONS FOR ORIENTAL BITTERSWEET (*CELASTRUS ORBICULATUS*) AND AMERICAN BITTERSWEET (*C. SCANDENS*). Stacey A. Leicht-Young, Noel B. Pavlovic, John A. Silander, Jr. and Ralph Grundel, Ecologists, U. S. Geological Survey, Porter, IN 46304, Professor, University of Connecticut, Storrs, CT 06269 and Ecologist, U. S. Geological Survey, Porter, IN 46304.

Celastrus orbiculatus is an invasive temperate liana introduced into the Northeastern United States in the 1860s. It can blanket the vegetation it grows on, causing damage to trees by weighing down the branches and by girdling the trunks. However, its native congener, *C. scandens*, is declining in the Northeast. In the Midwestern and Western United States, *C. scandens* is still abundant and can even grow adjacent to invasive *C. orbiculatus* in certain habitats such as the sand dune/forest ecotone. Despite some degree of overlap in habitat preferences, their growth rates are very different. Additionally, where both species occur, vegetative identification of the two species in the field can be highly ambiguous. We examined both species in a three year common garden study, and in natural settings, to differentiate them ecologically and morphologically. In the common garden study, *C. orbiculatus* had higher leaf number, relative growth rate, and aboveground biomass than *C. scandens*. Using morphological characteristics of both species growing naturally along a sand dune/forest ecotone, we built models for use in predicting which species was present given a suite of leaf and fruit traits. We confirmed that the two species can be discriminated effectively using fruit characters, notably fruit volume and seed number. Several leaf traits, such as length to width ratio and specific leaf area (SLA) can also discriminate between the species, but without the same predictive reliability of fruit traits. In addition, in mid-spring, the two species have different patterns of leaf-out. Land managers will be able to use this information to differentiate between the two species in the field and thereby control for the invasive *C. orbiculatus*, while preserving remaining populations of *C. scandens*.

THE INFLUENCE OF HABITAT AND LAND USE ON THE DISTRIBUTION AND ABUNDANCE OF EXOTIC PLANTS IN THREE GREAT LAKES NATIONAL PARKS. Noel B. Pavlovic, Stacey A, Leicht-Young, and Ralph Grundel, Ecologists, U.S. Geological Survey, Porter, IN 46304.

Understanding patterns of exotic species distribution across a landscape is the first step to successful exotic plant management. With this in mind, we sampled exotic and native plants at Indiana Dunes (N = 900 plots), Pictured Rocks (N = 1120), and Sleeping Bear Dunes (N = 1244) National Lakeshores from 1998-2000. Random transects with three plots were located across major vegetation strata. In each plot we assessed the frequency score of groundlayer species in seven nested subplots within a 4 by 2 m frame. Basal area of the five largest trees and identity of all shrubs and trees within 10 m radius were recorded. The contrast in exotic frequency among Picture Rocks (11% plots with exotics), Indiana Dunes (52%), and Sleeping Bear Dunes (46%) was likely the result of differing land use history. Pictured Rocks was logged and abandoned while the other two parks were logged earlier and had a longer history of agricultural and residential land use. To determine if the differences in exotic plant frequency between parks were due to land use history, we used correlation analysis and hierarchical partitioning to examine the relationships between richness of exotic species per plot and environmental, habitat, spatial trends, successional, and human disturbance variables across the latitudinal gradient represented by the three parks. Where present, exotics were nearly twice as dense at Sleeping Bear (4.37 ± 0.15 species per plot) than at Indiana Dunes (2.46 ± 0.17) and at Pictured Rocks (2.34 ± 0.09). The proportion of exotic richness explained by human disturbance versus environmental factors varied inversely with latitude. The importance of habitat, spatial trend, and succession in explaining exotic richness were relatively constant across the latitudinal gradient but successional variables were more important than habitat and spatial trends. These results confirm that the latitudinal gradient in exotic richness is related to human activity on the landscape.

MULTI-PRONGED STRATEGY FOR THE DEVELOPMENT OF BIOLOGICAL CONTROL FOR COMMON TANSY, *TANACETUM VULGARE* L., Monika A. Chandler, Alec S. McClay and Urs Schaffner, Research Scientist, Minnesota Department of Agriculture, St. Paul, MN 55101 USA, McClay Ecoscience, Sherwood Park, Alberta T8H 1H8 Canada, and Head Ecosystems Research, CABI Switzerland Centre, 2800 Delémont, Switzerland

Common tansy, *Tanacetum vulgare*, is an invasive plant of natural areas, pastures, forest and field margins, and rights of way. Brought to North America from Europe as a medicinal and ornamental plant, tansy escaped cultivation and is spreading throughout the northern United States and Canada. Tansy infestations are associated with loss of desirable vegetation, toxicity to humans and livestock, reduction in pasture carrying capacity, degradation of wildlife habitat, and hindering reforestation and restoration efforts. Herbicide control is costly and may not be an option for environmentally sensitive areas such as wetlands. A program for the development of biological control for common tansy was launched in 2006 by a joint United States and Canadian consortium. The program includes foreign exploration to identify candidate biological control insects and to study their host-specificity and their impact on the target weed. In addition, efforts continue to assess the current distribution of common tansy and to quantify its economic and ecological impacts in the invaded range.

INVASIVE SPECIES CONTROL ENCOMPASSING VARIOUS ASPECTS OF RESTORATION - URBAN TO RURAL. Steven B. Barker, Restoration Ecologist, JFNew, 708 Roosevelt Road, Walkerton, IN, 46574.

Northwest Indiana is a complex assortment of urban and rural environments, where intense industrial, commercial and residential developments mingle closely with high quality natural areas. The former is largely responsible for degraded, biologically deficient environments while the latter offers an opportunity for both preservation and restoration. Clearly, the challenge of invasive species control is both real and potent. The presentation will briefly cover the history of the Northwest Indiana landscape, current status of natural areas in the region, and highlights of restoration projects as they relate to invasive species.

COTTON YIELD AND FIBER QUALITY AS AFFECTED BY SIMULATED HERBICIDE DRIFT. Molly E. Marple, Kassim Al-Khatib, and Dallas E. Peterson, Graduate Research Assistant, Professor, and Professor, Department of Agronomy, Kansas State University, Manhattan KS 66506.

. Field experiments were conducted in 2004, 2005, and 2006 at Manhattan, KS to evaluate cotton injury and yield reduction from hormonal-type herbicides. The first experiment, conducted in 2004 and 2005, compared cotton response to 2,4-D amine, 2,4-D ester, dicamba, clopyralid, picloram, fluroxypyr, and triclopyr each applied at 0, 1/100, 1/200, 1/300, and 1/400 of the field use rates when cotton was in the 5 to 6 leaf stage. Field use rates for all experiments were 561, 561, 561, 280, 561, 210, and 561 g ai/ha for 2,4-D amine, 2,4-D ester, dicamba, clopyralid, picloram, fluroxypyr, and triclopyr, respectively. All herbicides caused visual injury to cotton, but injury symptoms and persistence varied among the herbicides. Cotton injury and yield reduction corresponded to herbicide rates and was greater for 2,4-D than the other herbicides evaluated. All rates of 2,4-D evaluated reduced cotton yield, while cotton yield was not reduced by any rates of clopyralid and triclopyr. A second experiment was conducted in 2005 and 2006 to determine the influence of cotton growth stage on crop injury and yield reduction from dicamba and 2,4-D amine. Dicamba and 2,4-D amine were applied at 0, 1/200 and 1/400 rates to cotton at the 3 to 4 leaf, pre-flower, mid-flower, and early boll stages of growth. Cotton yields were not reduced by any of the herbicide treatments in 2005. In 2006, cotton yield was reduced by the pre-flower treatment time, but not by the other applications. A third experiment was conducted in 2005 and 2006 to evaluate the effect of multiple exposures of 2,4-D drift on cotton. 2,4-D amine at 0, 1/400, 1/800, and 1/1200 rates was applied 1, 2 or 3 times, at 2 week intervals following the initial application timing at the pre-flower stage of cotton. Cotton injury and yield loss generally increased as the number of exposures increased. Cotton yield was reduced with multiple applications but not with single applications. Cotton injury from hormonal herbicide drift depends on the herbicide, herbicide rate, exposure stage, and number of exposures. 2,4-D was the most injurious hormonal herbicide to cotton, and yield loss was greatest when exposed at the pre-flower stage of growth and with multiple exposure events.

CLORANSULAM-METHYL + SULFENTRAZONE FOR FOUNDATION WEED CONTROL IN GLYPHOSATE TOLERANT SOYBEANS. Marvin E. Schultz*, David C. Ruen, Jeff M. Edwards, and Mark A. Peterson, Dow AgroSciences, Indianapolis, IN 46268.

Tank mixes of cloransulam-methyl + sulfentrazone were applied pre-plant to glyphosate tolerant soybeans in 2002 and 2006 to evaluate residual weed control prior to a planned post-emergence application of glyphosate. A total of 10 field trials were established in Midwest U.S. soybeans. Five trials in 2002 tested cloransulam-methyl + sulfentrazone at 11.7 + 93.3, 17.5 + 140, and 23.3 + 187 g ai/ha. Five additional trials conducted in 2006 included the same rates of cloransulam-methyl + sulfentrazone, plus three rates of cloransulam-methyl (FirstRate®) alone, sulfentrazone (Spartan) alone, cloransulam-methyl + flumioxazin (Gangster), chlorimuron-ethyl + metribuzin (Canopy), and *s*-metolachlor + metribuzin (Boundary). Rates tested were about 0.33X, 0.5X, and 0.66X of the full label rates. Weed control at 5-9 weeks after application (WAA) is reported in this paper.

Cloransulam-methyl + sulfentrazone exhibited a consistent weed control dose response across the three rates tested. The 17.5 + 140 g ai/ha rate provided excellent control of a wide range of broadleaf weeds; including velvetleaf, pigweed species, common waterhemp, common lambsqarters, Venice mallow, common purslane, prickly sida, eastern black nightshade, and common ragweed. However, this treatment only provided variable suppression and/or control of giant ragweed, morningglory species, common cocklebur, and grass weeds.

Cloransulam-methyl + sulfentrazone tank mixes provided better weed control than either herbicide used alone at the same rates. Cloransulam-methyl + flumioxazin treatments performed similar to cloransulam-methyl + sulfentrazone. Mixes of cloransulam-methyl with sulfentrazone or flumioxazin provided better general broadleaf weed control than chlorimuron-ethyl + metribuzin or *s*-metolachlor + metribuzin treatments. However, s-metolachlor + metribuzin provided better control of giant foxtail than all other treatments tested. No significant crop injury was observed with any treatment in these trials.

®FirstRate is a trademark of Dow AgroSciences LLC

EVALUATION OF CROP TOLERANCE WITH POST APPLIED TANK MIXES OF GLYPHOSATE WITH LORSBAN, FUNGICIDES, AND MICRONUTRIENT FERTILIZER IN SOYBEANS. David C. Ruen*, Sam M. Ferguson, and Bruce E. Maddy, Product Technology Specialists, Dow AgroSciences, LLC, Indianapolis, IN 46268.

Two field trials were conducted in 2006 in southern IL and southern WI to evaluate soybean injury when glyphosate tank mixes with insecticide, fungicide and micronutrient fertilizer treatments are applied late POST in Roundup Ready® soybean. Lorsban®-4E (chlorpyrifos) was the only insecticide tested. Fungicides tested included Laredo® EC (myclobutanil), Headline EC (pyraclostrobin) and Folicur 3.6F (tebuconazole). MAX-IN for Soybeans (0.2% Boron, 0.3% Iron, 3.2% Manganese, 0.01% Molybdenum, 2.1% Zinc analysis) was selected as the micronutrient foliar fertilizer. Both trials were kept weed free with maintenance applications of glyphosate prior to the POST applications at R3 stage of soybean. Crop injury was evaluated at 2, 7 and 14 DAA. Soybean plots were not taken to yield.

Crop injury, expressed as chlorosis and necrosis, was greatest at 7 DAA. Injury was 0-5% for all treatment combinations at the 1X use rates. At 2X use rates injury increased to 4-10% at 7 DAA with some replicate observations of up to 15% injury. Minor leaf necrosis was the only visible injury symptoms 14 DAA.

Compared to glyphosate + AMS alone, slight additive injury was observed as the insecticide or fungicide products were sequentially added. However, this additive effect was not statistically significant at either 1X or 2X use rates.

No significant interaction by insecticide, fungicide or micronutrient addition was observed, with one exception. Addition of MAX-IN to Folicur + Lorsban-4E + glyphosate + AMS at the 2X use rate resulted in noticeably greater crop injury than the two other 2X Folicur comparison treatments which did not include MAX-IN. This level of injury, however, was comparable to 2X use rates of MAX-IN + Lorsban-4E + glyphosate + AMS plus either Laredo or Headline fungicides.

®Lorsban is a trademark of Dow AgroSciences LLC
®Laredo is a trademark of Dow AgroSciences LLC
®Roundup Ready is a registered trademark of Monsanto Company.

Lorsban-4E is a Restricted Use Pesticide.

EFFECT OF LACTOFEN APPLICATION TIMING ON YIELD AND ISOFLAVONE CONCENTRATION IN SOYBEAN SEED. Kelly A. Nelson, George E. Rottinghaus, and Teak E. Nelson, Research Assistant Professor, Division of Plant Sciences, University of Missouri, Novelty, MO 63460, Clinical Associate Professor, Veterinary Medicine Diagnostic Laboratory, University of Missouri, Columbia, MO 65211, and Instructor, Department of Nursing, Truman State University, Kirksville, MO 63501

A postemergence application of the herbicide lactofen has increased phenolic compounds such as isoflavones in soybean plants. We hypothesized that lactofen increases isoflavone levels in seed when treated at the early R1 and R5 stages of development. Field research in 2002 and 2004 evaluated the effect of lactofen application timing and cultivar (Garst 3712, glyphosate-resistant; Big Bubba, high-protein; and Envy, edamame) on crop response and seed isoflavone concentration. Injury from lactofen at 70 g a.i. ha^{-1} was 7 to 15% seven d after treatment. Lactofen applied to Big Bubba in the R5 stage of development increased concentration of genistein 78 µg g^{-1}, daidzein 82 µg g^{-1}, and total isoflavones 169 µg g^{-1} compared to the non-treated control. Lactofen applied at the R5 stage of development increased Garst 3712 daidzein concentration 52 µg g^{-1}. Lactofen did not affect seed isoflavone concentration when applied at the R1 stage of development or when applied to Envy or Garst 3712 at the R5 development stage, but total isoflavone concentration increased 10% in Big Bubba when lactofen was applied at the R5 stage of development. Seed yield averaged over three cultivars was reduced 290 and 330 kg ha^{-1} when lactofen was applied in 2002 at R1 and 2004 at R5 stages of development, respectively.

WEED CONTROL PROGRAMS WITH GLUFOSINATE IN LIBERTYLINK SOYBEANS. Daren Bohannan, Michael Weber, John Cantwell, and Jayla Allen, Bayer CropScience, Research Triangle Park, NC.

Since the first introduction of glyphosate tolerant crops in the mid 1990's, US growers have become accustomed to the use of a non-selective herbicides. Rapid adoption of this technology in some crops including soybeans has dramatically changed the way in which growers approach weed control. Some areas of the Midwest have seen a market share of glyphosate tolerant soybeans approach 95%. With the increase in acreage planted to glyphosate tolerant soybeans, most basic manufacturers have abandoned the discovery for new and novel herbicides for soybeans. Coupled with the rapidly increasing acres of glyphosate tolerant corn, it would be expected that more glyphosate resistant weeds will develop and spread across the midwest. Glufosinate has a unique mode of action that can provide an alternative control measure for weeds resistant to glyphosate.

Weed control trials for Liberty Link soybeans were conducted by Bayer Crop Science and Midwestern universities. In 2006, 21 locations evaluated the use of glufosinate in LibertyLink soybeans for general weed efficacy across a broad spectrum of grass and broadleaf weeds. Optimum weed control was obtained when a preemergence herbicide was followed by glufosinate across all species.

IMPACT OF WEEDS THAT SURVIVE THE FIRST GLYPHOSATE APPLICATION IN SOYBEAN. Bryan G. Young, Julie M. Young, Joseph L. Matthews, Associate Professor and Researchers, Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901.

Sole reliance on glyphosate for weed management in soybean continues to be the major strategy implemented by growers. With increasing commercial frequency, the first in-season application of glyphosate may not provide complete weed control and is influenced by weed size, species, and adverse environmental conditions for foliar herbicide activity. Some commercial instances have been reported where glyphosate provided minimal suppression of certain weed species which results in the need for a second application of glyphosate within weeks of the first herbicide application. Questions have developed concerning the extent of competition the surviving weeds may apply on the developing soybean crop in terms of potential yield loss. Even though a second glyphosate application may provide complete weed control, the weeds were not removed from the crop at the desired timing with the initial glyphosate application. Field research was conducted over three years to determine the competitive load from the weeds that may potentially survive glyphosate applications in soybean. A rate titration of glyphosate was applied to weeds at 10 to 20 and 25 to 35 cm in height. This resulted in a gradient of minimal to high levels of weed control to simulate a range of possible glyphosate failures. Two weeks after treatment a full rate of glyphosate was applied to remove any weeds that survived the initial glyphosate application.

Yellow nutsedge, common ragweed, common waterhemp, and giant ragweed were controlled to a lesser extent by the reduced rates of glyphosate than other weed species evaluated. Even though the growth of these weeds was suppressed to a certain degree by the lowest rate of glyphosate utilized (54 g ae/ha), soybean yield data suggests these weeds did compete with soybean over a two-week period, pooled over the two initial glyphosate application timings. The magnitude of soybean yield loss varied by the extent of weed control achieved with the initial glyphosate application as well as the environmental conditions over years and the primary weed species present. This research confirms that any potential soybean yield loss as a result of weed survival from sublethal rates of glyphosate may be greater than the additional cost for higher application rates of glyphosate.

EVALUATION OF PROGRAMS FOR THE MANAGEMENT OF GLYPHOSATE-RESISTANT COMMON WATERHEMP IN SOYBEAN. Travis R. Legleiter, Nick Monnig, and Kevin Bradley, University of Missouri, Columbia, MO 65211

Field experiments were conducted in 2006 to evaluate various preemergence (PRE) and postemergence (POST) herbicide treatments for the control of glyphosate-resistant common waterhemp (*Amaranthus rudis*) in glyphosate-resistant soybean. In the first experiment, visual control ratings and the number of common waterhemp plants/9m^2 remaining at harvest were evaluated in response to PRE-only, PRE followed by POST and POST-only herbicide programs. PRE herbicide treatments evaluated included flumioxazin at 0.09 kg/ha, sulfentrazone at 0.28 kg/ha, alachlor at 2.8 kg/ha, and *S*-metolachlor plus metribuzin at 1.54 kg/ha plus 0.36 kg/ha while POST treatments included 0.86 kg/ha glyphosate, 0.14 kg/ha lactofen, 0.42 kg/ha aciflourfen, 0.86 kg/ha glyphosate plus 0.14 kg/ha lactofen, and 0.86 kg/ha glyphosate plus 0.42 kg/ha aciflourfen. All PRE followed by POST programs provided greater than 65% common waterhemp control 3 months after planting (MAP) and resulted in 16 or less common waterhemp plants/9 m^2 at harvest. PRE-only applications of sulfentrazone and *S*-metolachlor + metribuzin provided better visual common waterhemp control 3 MAP than applications of flumioxazin or alachlor but no differences in the number of common waterhemp plants/9m^2 remaining at harvest were observed between any of the PRE-only programs evaluated. All POST-only treatments provided less than 25% visual control of common waterhemp 3 MAP. POST-only treatments also resulted in higher numbers of common waterhemp plants/9m^2 remaining at harvest than PRE-only or PRE followed by POST programs. Lowest soybean yields occurred with POST-only programs while no differences in soybean yield were observed between PRE-only and PRE followed by POST programs except for programs that contained PRE applications of alachlor. The addition of either POST treatment to a PRE alachlor application resulted in higher soybean yields than applications of alachlor alone.

In a second experiment, POST applications of glyphosate at 0.86 kg/ha, 1.74 kg/ha, 3.47 kg/ha, and 6.94 kg/ha and combinations of glyphosate at 0.86 kg/ha plus lactofen at 0.14 kg/ha, fomesafen at 0.19 kg/ha, acifluorfen at 0.42kg/ha, carfentrazone at 0.004 kg/ha, cloransulam at 0.018 kg/ha, or 2,4-DB at 0.035 kg/ha were made to common waterhemp less than 15 cm in height to evaluate resistance of this population at the field level. Prior to application, 20 common waterhemp plants per plot were flagged and survival of these plants in response to each treatment was monitored until six weeks after treatment (WAT). At 6 WAT, 98% of the common waterhemp population survived applications of glyphosate at the labeled rate (0.86 kg/ha) while 53% of the populations survived eight times the labeled glyphosate use rate (6.94 kg/ha). Additionally, 90% or more of the common waterhemp survived applications of glyphosate in combination with lactofen, acifluorfen, fomesafen, or carfentrazone, suggesting the possibility of resistance to protox-inhibiting herbicides in this population as well. This possibility will be examined in future experiments.

PREFIX: EARLY SEASON WEED CONTROL AND RESISTANT WEED MANAGEMENT IN SOYBEAN. Stott Howard, Dain Bruns, Scott Cully and Don Porter, Syngenta Crop Protection, West Des Moines, IA 50266.

Prefix consists of two proven active ingredients, s-metolachlor and fomesafen, for preemergence weed control in both conventional and glyphosate-tolerant soybeans. Combining these active ingredients makes for a highly effective preemergence herbicide with several benefits: two modes of action to help prevent the development of resistant weeds; excellent control of broadleaf and grass weeds (including glyphosate and ALS resistant biotypes) as well as problematic species such as common ragweed, waterhemp, lambsquarters, foxtails, pigweeds and smartweeds; early season residual weed control that broadens the application window for glyphosate; and excellent soybean safety. As a foundation treatment, Prefix has been demonstrated in Syngenta and university trials to be an effective component of a season-long soybean weed control program.

CROP ROTATION AND WINTER WEED MANAGEMENT EFFECTS ON THE WEED SEEDBANK AND SOYBEAN CYST NEMATODE DENSITY. J. Earl Creech, Valerie A. Mock, William G. Johnson, Virginia R. Ferris, Jamal Faghihi, and Andreas Westphal, Graduate Research Assistants, Associate Professor, Professor, Extension Nematologist, 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 alternative hosts for SCN in the greenhouse. However, the importance of winter weed management in managing SCN in the field has not been documented. The objective of this research was to evaluate the impact of winter annual weed management and crop rotation on SCN population densities, winter annual weed populations, and crop yield. Field trials were established in the fall of 2003 at the Agronomy Center for Research and Education in West Lafayette, IN and at the Southwest Purdue Agricultural Center in Vincennes, IN. The experimental design was a randomized complete block split-plot with six replications. The main plots consisted of two crop rotations: continuous soybean and a 2-yr rotation of soybean-corn. The subplot treatments were comprised of various herbicide application timings and cover crops. Cover crops included fall-seeded annual ryegrass (*Lolium multiflorum*) and winter wheat (*Triticum aestivum*). Winter weed control timings were 1) a non-treated control, 2) fall and spring control, 3) spring control, and 4) fall control. After establishment, the plots to which the main- and sub-plot factors were applied remained fixed throughout the entire experiment to determine the cumulative treatment effects over time. To date, winter annual weed management has not influenced SCN egg density but crop rotation and SCN resistant cultivars have proven to be important SCN management tools. The failure of winter weed management to impact SCN population density is likely due to the low weed pressure in the plot area at the onset of the experiment. Herbicides have been more effective than cover crops at reducing the amount of weed seed in the soil seedbank. Cover crops negatively influenced corn and soybean yield at West Lafayette but not Vincennes.

THE TIMING OF OPTIONS FOR CONTROL OF GLYPHOSATE RESISTANT VOLUNTEER CORN. Randall S. Currie, Brandon Fast, Don Murray, and John Fenderson, Associate Professor, Kansas State University, Garden City, KS 67846, Graduate Research Assistant, Professor, Oklahoma State University, Stillwater, OK 74078, and Monsanto Corporation Scientist, Kiowa, KS 67070

In southwestern Kansas, when enough irrigation water is available, corn can be profitably grown continuously without rotation for more than 20 years. With increasing use of glyphosate-resistant corn hybrids, volunteer corn has become a much more difficult weed to control. It was the objective of these studies to determine a non-glyphosate tank mix to control this emerging weed problem. Volunteer corn was simulated by planting standard glyphosate-resistant corn hybrids in randomized complete-block experiments with 4 or more replications conducted near Stillwater, Oklahoma, and Garden City, Kansas. In Stillwater, all rates of clethodim at 0.015 lbs /a or higher provided 100% control of 2-leaf corn. This rate produced 90% control of 3-leaf corn and needed to be doubled to provide 100% control. In a second study, clethodim at 0.06 lbs/a completely controlled 3-leaf or 6-leaf corn, 21 DAT. In Garden City clethodim was applied at 0, 0.015, 0.03 and 0.06 lbs /a to 4-leaf corn and 8-leaf corn in a balanced factorial experiment. Greater than 90% control was produced by applications of 0.06 lbs /a of clethodim 21 DAT at both growth stages. However, no rate or timing produced 100% control. Corn recovered to varying degrees and was harvested for grain as an index of injury. The lowest clethodim rate recovered and had a yielded no different than the control. When this rate was applied to 8-leaf corn, yield was reduced 56% .Clethodim applied to 4-leaf corn at 0.03 lbs /a reduced, yielded 58%. In contrast when this application was delayed to the 8-leaf stage, yield dropped 93%. Regardless of timing of application, corn treated with 0.06 lbs/a had a yielded reduced 97%. Depending on the objectives of a producer, these treatments would have been commercially acceptable. These studies suggest that clethodim might provide the best control when applied early at lower rates or applied late at the higher rates.

RESPONSES OF TOLERANT AND SENSITIVE SWEET CORN INBREDS AND NEAR ISOGENIC HYBRIDS TO POSTEMERGENCE HERBICIDES WITH DIFFERENT MODES OF ACTION. *Dean S. Volenberg, Martin M. Williams II, Jerald K. Pataky, and Dean E. Riechers, Agricultural Agent Univ. of Wisconsin Cooperative Extension, Door County, WI 54235, Assistant Professor, Department of Crop Sciences USDA-ARS, Univ. of Illinois, Urbana, IL 61801, Professor and Associate Professor, Department of Crop Sciences, Univ. of Illinois, Urbana, IL 61801.

While certain sweet corn hybrids are consistently injured by applications of nicosulfuron or mesotrione, other hybrids are only occasionally injured. Recent research indicated a single gene in a nicosulfuron-sensitive inbred (CR1) is associated with sensitivity to mesotrione, dicamba+diflufenzopyr, carfentrazone, foramsulfuron, and primisulfuron. Two sets of experiments were undertaken to determine if plants heterozygous for the gene in inbred CR1 had responses that were intermediate to CR1 and a nicosulfuron-tolerant inbred (CR2). The first experiment characterized herbicide dose response of two- to three-leaf sweet corn plants (CR1, CR2, and their respective F_1 hybrid) to nicosulfuron, mesotrione, topramezone, and dicamba. Based on visual assessment of injury eight days after treatment (DAT), inbred CR2 was more tolerant to nicosulfuron, mesotrione, topramezone, and dicamba compared to inbred CR1, and the F_1 hybrid had a response intermediate to inbreds CR1 and CR2. To further characterize the effect of gene dosage on herbicide tolerance in a uniform genetic background, S_5 near isolines were developed from the selfed F_1 hybrid. After five generations of selfing, homozygous sensitive or homozygous tolerant lines were selected from segregating S_5 families. S_5 near isolines from different families were crossed to produce nicosulfuron homozygous tolerant (TT), nicosulfuron homozygous sensitive (tt), and heterozygote (Tt) near-isogenic hybrids. The second experiment characterized postemergence herbicide dose response of one- to two-leaf stage near isogenic hybrid sweet corn plants (TT, Tt, and tt hybrids) to tritosulfuron, mesotrione, topramezone, dicamba, and atrazine 14 DAT. Similar to the results above, the TT hybrid was more tolerant to mesotrione compared to the tt hybrid and the heterozygote Tt hybrid had a response intermediate to TT and tt (based on plant dry biomass). However, the Tt hybrid biomass response to tritosulfuron was not intermediate between TT and tt hybrids, as the GR_{50} values for TT, Tt, and tt were 54, 112, and 25 g ai ha^{-1}, respectively. The responses of TT, Tt, and tt hybrids to topramezone, dicamba, and atrazine were similar based on plant dry biomass. Plants heterozygous for the gene in inbred CR1 clearly have intermediate responses to mesotrione. Although the heterozygous F_1 hybrid had responses to topramezone and dicamba that were intermediate to inbreds CR1 and CR2 in the first study, the heterozygous Tt hybrid was similar in responses to TT and tt hybrids in the second study. The first set of experiments used visual ratings of crop injury, while the second set of experiments used plant biomass to assess injury. One possible explanation for inconsistent results with topramezone and dicamba is that 14 DAT was not sufficient time to detect differences in biomass among near isogenic hybrids to these herbicides. Alternatively, the TT, Tt, and tt hybrids may partition assimilates differently after exposure to topramezone and dicamba, resulting in visual height differences among near isogenic hybrids, but with similar biomasses. Sweet corn hybrids with variable response to mesotrione, and perhaps additional herbicides, may be the result of being heterozygous for the gene in inbred CR1.

MODE OF ANTAGOISM OF SULFONYLUREA HERBICIDES WITH MESOTIONE. Christopher L. Schuster, Kassim Al-Khatib, and J. Anita Dille, Graduate Student, Professor, Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66502.

Studies were conducted to determine if absorption, translocation, or metabolism was the basis for the reduction in sulfonylurea herbicide efficacy on foxtail species when mesotrione was tank mixed with sulfonylurea herbicides. Green foxtail and yellow foxtail plants were grown in the greenhouse and treated at the 4-leaf stage with ^{14}C-labeled nicosulfuron or rimsulfuron applied alone or with mesotrione or mesotrione + atrazine. Absorption of nicosulfuron was greater in green foxtail and yellow foxtail 7 days after treatment (DAT) when applied alone, as compared to tank mixing the herbicide with mesotrione or mesotrione + atrazine. Nicosulfuron applied alone translocated 9% more nicosulfuron to the treated tiller in green foxtail, as compared to nicosulfuron tank mixed with mesotrione or mesotrione + atrazine 7 DAT. Translocation of nicosulfuron in yellow foxtail, however, was similar when nicosulfuron was applied alone in combination with mesotrione or mesotrione + atrazine. Tank mixing mesotrione with rimsulfuron did not reduce the absorption of rimsulfuron in green foxtail; however, the addition of mesotrione + atrazine resulted in a 20% decrease in rimsulfuron absorption 7 DAT, as compared to rimsulfuron applied alone. Yellow foxtail absorption of rimsulfuron at 7 DAT was decreased by 11 and 20% when tank mixed with mesotrione or mesotrione + atrazine, respectively. Rimsulfuron applied alone resulted in 6% more herbicide being translocated to the treated tiller in green foxtail at 7 DAT, as compared to an application of mesotrione + atrazine and rimsulfuron. Translocation of rimsulfuron in yellow foxtail was similar when applied alone or in combination with mesotrione or mesotrione + atrazine. Nicosulfuron and rimsulfuron metabolism in both species was similar when applied alone or in combination with mesotrione or mesotrione + atrazine. The reduction of nicosulfuron and rimsulfuron efficacy when tank mixed with mesotrione or mesotrione + atrazine in green foxtail was due to decreased absorption and translocation of nicosulfuron and rimsulfuron. The reduced yellow foxtail efficacy of sulfonylurea herbicides tank mixed with mesotrione is due to lower absorption.

ARTIFICAL SELECTION OF GLYPHOSATE RESISTANCE. Ryan M. Lee, Patrick J. Tranel, and Robert E. Pruitt. Postdoctoral Research Assistant, Associate Professor, Department of Crop Sciences, University of Illinois, Urbana, IL 61801, Professor, Department of Botany and Plant Pathology Purdue University, West Lafayette, IN 47907.

Despite heavy selection pressure, glyphosate resistant weeds have been rare events. Over the past few years, glyphosate resistance in weedy species has been found and the list of resistant weeds has been growing steadily. Resistance in these species was originally hypothesized to be due to an amino acid substitution **EPSPS** protein, the target site of glyphosate. Specifically, a proline was changed to a serine or threonine in the **EPSPS** from these resistant species. These sequences have been found in glyphosate resistant biotypes of goosegrass (*Eleusine indica*), rigid ryegrass (*Lolium rigidum*) and horseweed (*Conyza canadensis*). However, multiple mutageneses of wild-type *Arabidopsis* have yielded no glyphosate resistant mutants suggesting that no single gene is sufficient to confer resistance to glyphosate. Based on these data it is hypothesized that **EPSPS** harboring either a serine or threonine in place of the active site proline is necessary but not sufficient to confer glyphosate resistance. To test this hypothesis transgenic *Arabidopsis* plants were generated that harbor one of two forms of the *EPSPS.* These plants were then mutagenized and mutant progeny were screened for second-site enhancers of resistance.

Arabidiopsis contains two *EPSPS* genes located on chromosome 1 and 2. Preliminary results indicate that analogous mutations in these genes do not confer the same level of resistance in transgenic plants. Because the sequences of the proteins encoded by these genes are 90% identical, it is thought that the differences in resistance provided by these transgenes may be due to transcriptional characteristics based on regulatory sequences. Genetic screens of mutagenized populations have isolated mutants exhibiting an enhanced glyphosate-resistance phenotype.

LOSING TOLERANCE FOR CURRENT DEFINTITIONS OF RESISTANCE (MAYBE WE'RE JUST TOO SENSITIVE). Mark M. Loux and Jeff M. Stachler, Professor and Weed Science Extension Program Specialist, Dept. of Horticulture and Crop Science, The Ohio State Univ., Columbus, OH 43210.

Current guidelines for confirmation of herbicide resistance have been developed based on the relatively high levels of resistance that occur for several of the most used herbicide sites of action. Research conducted over the past several years by The Ohio State University and Purdue University indicates that it is possible for lambsquarters and giant ragweed to develop a low level of glyphosate resistance. This type of resistance is more difficult to accurately characterize, compared with higher levels of resistance typical of ALS inhibitors, for example. Results of greenhouse dose response studies can be inconsistent from experiment to experiment, due to the low level of resistance, the genetic variability in response to glyphosate among plants from a composite seed sample, and changes in the greenhouse environment. Consequently, it is necessary to conduct field studies in addition to the greenhouse studies, where multiple biotypes are compared under the same environmental conditions in the field. It is also necessary to conduct field studies using various glyphosate rates and application sequences, with the goal of determining how control is affected in glyphosate-resistant crops. The high level of resistance usually associated with ALS resistance tends to result in a complete lack of control, regardless of rate or number of applications. Plants with a low level of glyphosate resistance may still be controlled by higher rates and multiple applications of glyphosate, but this should not preclude these biotypes from being classified as resistant. When this evidence is considered relative to the steady increase in prevalence of giant ragweed in growers' fields, we are forced to conclude that resistance to glyphosate is present and will become more widespread.

Weed scientists have largely failed to prevent herbicide resistance for any number of reasons. The most we can hope to accomplish is to identify resistant species soon after their discovery in a few fields, and to implement educational programs soon enough to prevent additional growers from experiencing weed control failures and substantial increases of the resistant biotype in the seed bank. The earlier in the development of resistance that we can accomplish this, the more successful we will be at preventing others from having the same problem. The low level of resistance to glyphosate can make it difficult to be absolutely certain that giant ragweed or lambsquarters is truly resistant, per current resistance definitions. However, the increased incidence of ineffective control of these species in the field would dictate that more effective control measures are necessary, regardless of the cause of the problem. Basing our recommendations on the assumption that resistance is occurring would appear to have few disadvantages, especially when evidence tends to support that resistance has developed. Moreover, there is considerable overlap in the recommendations intended to improved control of resistant versus non-resistant biotypes, and there would thus appear to be few disadvantages to initiating education on management of resistant biotypes.

MOLECULAR METHODS TO STUDY GLYPHOSATE-RESISTANT PALMER AMARANTH. Todd A. Gaines, Philip Westra, and Christopher Preston. Graduate Student and Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523 and Lecturer, School of Agriculture, Food, and Wine, University of Adelaide, Australia.

Recent reports of glyphosate-resistant Palmer amaranth have been investigated using several molecular methods. Seeds were obtained from scientists in Georgia and screened with an in-vivo shikimate accumulation assay. Using a range of glyphosate concentrations from 100 to 2,000 µM, susceptible plant leaf discs accumulated shikimate in 100 µM glyphosate while resistant plant leaf discs accumulated detectable shikimate only in 2,000 µM glyphosate. Candidate glyphosate resistance mechanisms under investigation include mutations in EPSPS and over-expression of EPSPS. Gene sequences have been obtained for 1,056 base pairs of EPSPS from resistant and susceptible plants. These results have been compared using current bioinformatics protocols to determine whether any detected mutations may be significant. Expression profiling using reverse-transcriptase PCR has been used to determine whether EPSPS is over-expressed in resistant plants. These molecular methods are useful to determine why Palmer amaranth is resistant and to identify and develop more rapid resistance diagnostic tools. Molecular biology techniques have been applied in weed science for some time and training for graduate students in molecular methods is increasingly important and valuable.

ONE PASS OR TWO, WHAT WOULD A PRE DO? Jeffrey L. Gunsolus, Lisa M. Behnken, Fritz R. Breitenbach, Jodie K. Getting, Milton J. Haar and Thomas R. Hoverstad, Professor, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108, Regional Extension Educator, Integrated Pest Management Specialist, University of Minnesota, Rochester, MN 55904, Scientist, Assistant Professor, University of Minnesota, Lamberton, MN 56152, and Scientist, University of Minnesota, Waseca, MN 56093.

Since the introduction of glyphosate-resistant soybean and corn in 1996 and 1998, respectively, Minnesota producers have rapidly adopted this technology. By 1999, 48% of the soybean acres were treated with glyphosate, and by 2005 48% of the corn acres were treated with glyphosate. Concurrent with this increase in glyphosate use has been a decline in the use of soil-applied residual herbicides. In 1996, 62% of Minnesota's soybean acres and 73% of the corn acres were treated with a soil-applied residual herbicide while the most recent survey data indicate that only 15 % of the soybean acres (2004 data) and 49% of the corn acres (2005 data) were still treated with a soil-applied residual herbicide. What value, if any, does the soil-applied residual herbicide provide to the producer growing glyphosate-resistant corn and soybean?

Field research was conducted in 2004 and 2005 to investigate the effect of time of glyphosate application on weeds 5, 10, 15, 20, and 25 cm in height on weed control, grain yield, and consistency of economic performance. Concurrent with the one-pass glyphosate application treatments (0.84 kg ae ha^{-1}) were sequential treatments of a one-half label use rate of acetochlor in corn and s-metolachlor&metribuzin in soybean followed by a postemergence application of glyphosate applied on the same day as the one-pass glyphosate treatments. Control treatments included a one-half label use rate of acetochlor (corn) and s-metolacholor&metribuzin (soybean) and a two-pass glyphosate application to weeds 10 cm in height followed by an application to late-emerging weeds at 5 to 10 cm in height. All corn and soybean plots were planted in 76-cm rows.

Studies were conducted at nine site-years for corn and 11 site-years for soybean on a wide range of common summer annual grass and broadleaf weeds. Corn was more sensitive than soybean to early-season weed competition. In corn, annual weed populations that exceeded 15 cm in height at the time of glyphosate application resulted in a significant yield decrease. Across nine site-years, the time interval between the 15- and 20-cm period of weed removal was only 3 to 7 days. In soybean, glyphosate application to weeds before they reached 15 cm in height resulted in a significant yield reduction. Soybean consistently tolerated early-season weed competition better than corn. Economic analysis of the consistency of economic return across site-years indicated that one application of glyphosate in corn did not maximize yield or economic return; however, in soybean one glyphosate application, when weeds were 15 to 20 cm in height, did maximize yield and economic return. In soybean, the one-half label rate of s-metolacholor&metribuzin followed by glyphosate did not provide favorable economic returns. In corn, the one-half label rate of acetochlor followed by glyphosate did provide a favorable economic return due to the reduction in early-season weed competition. In corn and soybean, the two-pass glyphosate application treatment provided favorable yield and economic return; however, there is greater economic risk with this weed control tactic in corn than soybean due to the need for more precise early-season weed control in corn. The soil-applied residual herbicide does provide economic value to the producer who grows glyphosate-resistant corn by reducing the risk associated with early-season weed competition. The soil-applied residual herbicide also provides a level of chemical diversification that may reduce the risk of developing herbicide-resistant weeds or weed species shifts.

TEACHING PESTICIDE APPLICATION TECHNOLOGY. Robert N. Klein, Professor University of Nebraska West Central Research and Extension Center, North Platte, NE.

2006 activities included a workshop session at the 12 Crop Protection Clinics held across the state in January with an attendance of 1537 on “Doing a Professional Job of Pesticide Application.” The 2006 Nebraska Guide for Weed Management, EC130 included a section on Mixing Herbicides, Herbicides and Fertilizer Compatibility, Using UAN to Keep Sprayer From Freezing, Herbicide Application , Soil and Postemergence Application Pointers and Sprayer Set-up, Spray Boom Set-Up on Field Sprayers, Calibration of Sprayers, How to Spray a Field to Prevent Overlap and Reduce Drift Injury, Reducing Drift, Cleaning a Sprayer and Spray Additives. Sprayer Technology is also taught at the Custom Applicator 3-Day School held each year which attracts more than 100. Materials have been prepared and are part of the Pesticide Applicator Training for private applicators by the extension educators. In 2006 a new two day Pesticide Application Course was started. Many other events feature training in pesticide application including Agronomy 220, county and area workshops, outstate workshops and also answering many questions on pesticide application. Most of the training includes the use of nozzle kits, spray booms, and other training materials such as NebGuides.

GROWER UTILIZATION OF ROUNDUP READY CROPS AND PERCEIVED PERFORMANCE OF GLYPHOSATE-BASED WEED MANAGEMENT SYSTEMS. Bryan G. Young, Southern Illinois University, Carbondale, IL 62901; Luke A. Farno and David R. Shaw, Mississippi State University, Mississippi State, MS 39762; Micheal D. K. Owen, Iowa State University, Ames, IA 50011; Stephen C. Weller, Purdue University, West Lafayette, IN 47907; John W. Wilcut, North Carolina State University, Raleigh, NC 27695; Robert G. Wilson, University of Nebraska, Scottsbluff, NE 69361.

A grower survey (n=1,195) was conducted in six states, Illinois, Indiana, Iowa, Mississippi, Nebraska, and North Carolina from November 2005 to January 2006 to characterize the historical utilization of Roundup Ready (RR) crops, discern herbicide use patterns, and gain grower insight on the performance of glyphosate- based weed control systems. The participants were selected randomly from a list of growers who have used RR seed technology and the sample size for each state represented was near 200.

The most common crop rotations included RR soybean rotated with a non-RR crop (freq 32%), RR corn rotated with RR soybean (freq 26%), and continuous RR soybean (freq 20%). A continuous RR cotton rotation was cited by approximately 25% of the grower respondents in Mississippi and North Carolina. Growers in all cropping rotations indicated weed pressure decreased after utilizing a RR crop. The weed species creating the greatest challenge for growers in RR corn/RR soybean rotation or a RR soybean non-RR crop rotation was waterhemp according to 13 and 9% of respondents, respectively. The weed species creating the greatest challenge for growers in RR cotton rotations was morningglory (21 to 26% of the respondents). Growers indicated the amount of conventional tillage was reduced after the adoption of RR crops. However, the availability of RR seed traits was not cited as the major reason why growers decided to reduce tillage inputs.

Less than 36% of the growers in a continuous RR soybean, continuous RR corn, or a RR corn/RR soybean rotation indicated that weed resistance to glyphosate is a concern. Conversely, 55 to 64% of growers utilizing RR cotton in any crop rotation were concerned about weed resistance to glyphosate. The most common strategy to manage potential glyphosate weed resistance cited by growers was to use the correct label rates of herbicides at the proper timing for the size and type of weeds present.

WEED PREVALENCE IN THE "I" STATES. Dawn E. Nordby, Robert G. Hartzler, Palle Pedersen, and William G. Johnson, Extension Specialist, Department of Crop Sciences, University of Illinois, Urbana, IL 61801, Professor and Professor, Department of Agronomy, Iowa State University, Ames, IA 50010, Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47097.

Every agronomic field has a weed infestation capable of causing significant economic damage if weeds are not effectively controlled. The most effective weed management programs utilize a combination of control strategies, including cultural, mechanical and chemical tactics. In the past decade weed management programs for corn and soybean in the North Central Region have become increasingly dependant on herbicides. Of particular concern is the reliance on glyphosate in soybean, with glyphosate resistant soybean planed on 80% of the acres. This practice results in glyphosate being used in a manner that enhances the potential for shifts in weed communities.

To evaluate the impact of cropping systems and herbicide use patterns on weed community shifts a field survey was conducted in the spring and late summer of 2004 and 2005 in Iowa, Illinois and Indiana. Sites were selected to ensure fields with a range in tillage and glyphosate use intensity. A total of 48, 37, and 30 fields were surveyed in Illinois, Indiana and Iowa, respectively.

The predominant weeds found in the different tillage systems varied with state. In no-till fields, winter annuals were discovered quite frequently throughout Illinois and Indiana, while very few were found in Iowa. Over 40% of the no-till sites in Illinois and Indiana contained chickweed, speedwell, dandelion, purple deadnettle, and wild garlic. Iowa no-till sites contained far fewer weeds (five fields with no weeds at all). In Iowa, waterhemp had the greatest occurrence, with 44% of sites sampled containing this weed, followed by giant foxtail and lambsquarters with 22% of sites infested with either of these two weeds.

The diversity of weed species found at conventional tillage sites decreased from Indiana to Iowa. Seventy-two weed species were identified as escaping weed management tactics in Indiana, while only ten weeds were found in Iowa. Summer annuals such as Eastern black nightshade, velvetleaf, giant foxtail, and prickly sida were the most frequent weeds (greater than 33% of fields infested) in Indiana. Illinois sites contained velvetleaf, giant foxtail, morningglory species, and waterhemp at greater than 25% occurrence. Whereas, waterhemp, giant foxtail, and velvetleaf were found in 40%, 37%, and 25% of Iowa sites, respectively.

MANAGEMENT OF GIANT RAGWEED POPULATIONS THAT ARE DIFFICULT TO CONTROL WITH GLYPHOSATE. Jeff M. Stachler, Mark M. Loux, William G. Johnson, and Andrew M. Westhoven, Weed Science Extension Program Specialist and Professor, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210 and Associate Professor and Graduate Student, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907-2054.

Over the past several years, Ohio and Indiana growers have experienced increasing difficulty controlling giant ragweed in glyphosate-resistant soybeans. In preliminary greenhouse studies with seed collected from problem fields, we observed a reduced response to glyphosate for a number of populations, which appeared to be indicative of glyphosate resistance. These populations were mostly from continuous glyphosate-resistant soybean fields that had been treated with glyphosate exclusively for a number of years. Field and greenhouse studies were conducted in 2006 with four giant ragweed biotypes from Ohio and Indiana to determine: 1) their response to foliar application of glyphosate, in comparison to two sensitive biotypes; and 2) whether they could be controlled with glyphosate-based weed management programs, when glyphosate was integrated with other herbicides.

In a field study where the resistant biotypes were compared with sensitive biotypes, a reduced response to glyphosate was observed for the resistant biotypes compared to two sensitive biotypes. Glyphosate was applied at 0.84 and 2.5 kg a.e./ha to plants 5 to 51 cm tall. Glyphosate was applied again at 1.7 kg/ha three weeks later to approximately half of the plants treated with 0.8 kg/ha initially. A total of 8 to 26 plants were treated per replication for the initial application. Glyphosate applied twice, or once at the higher rate, provided at least 93% control of the two sensitive populations. Control of the four suspect populations ranged from 50 to 76% for two applications of glyphosate, and from 45 to 81% for the single application at 2.5 kg/ha. While a maximum of only 2% of the plants from the sensitive populations showed substantial regrowth when treated twice, or once at the higher rate, the number of plants from the four suspect populations with substantial regrowth ranged from 5 to 59%.

In field studies conducted in no-tillage, glyphosate-resistant soybeans at the site of seed collection, most effective control resulted from a preplant application of glyphosate plus 2,4-D ester, followed by either: 1) two postemergence applications of glyphosate, 1.7 kg/ha followed by 8.4 kg/ha three weeks later; or 2) postemergence application of fomesafen (0.34 kg ai/ha) followed by glyphosate at 0.84 kg/ha three weeks later. Where the preplant treatment included residual herbicides, cloransulam at 24 g ai/ha plus flumioxazin at 72 g ai/ha, it was possible to control resistant plants with two postemergence applications of glyphosate at 0.84 kg/ha. The resistant biotypes were adequately controlled by herbicide programs consisting exclusively of two applications of glyphosate at only one of the four sites. Similarly, one postemergence glyphosate treatment did not effectively control resistant biotypes, regardless of the type of preplant treatment. While it was possible to obtain greater than 95% control of giant ragweed with the treatments mentioned here, these treatments did not completely prevent giant ragweed seed production. The population density at the end of the season, for plants that produced seed, ranged from 0 to 1.5 plants m^{-2} for the most effective treatments. However, when only plants taller than the soybeans were considered, the number of plants with seed ranged from 0 to 0.1 plants m^{-2} for these treatments. For these same treatments, up to 13% of plants with seed at the end of the season were known to survive postemergence glyphosate treatments. However, among all treatments and sites, up to 96% of the plants with seed at the end of the season were known to survive postemergence glyphosate treatments.

DEVELOPMENT AND UTILIZATION OF AN INTEGRATED PEST MANAGEMENT ASSESSMENT TOOL. Lisa M. Behnken, Ryan P. Miller, and Fritz R. Breitenbach, Extension Professor, University of Minnesota, Rochester Regional Center, Rochester, MN 55904-4915, Assistant Extension Professor, University of Minnesota, Albert Lea Regional Center, Albert Lea, MN 56007-4001, Associate Extension Professor, University of Minnesota, Rochester Regional Center, Rochester, MN 55904-4915.

The University of Minnesota Integrated Pest Management (IPM) Assessment for Field Crops in Southern Minnesota was adapted from the University of Wisconsin Pest Management Assessment for Field Corn (12-6-01). The Minnesota IPM assessment was started in 2003 and has been revised yearly through 2006 to provide the most accurate and relevant IPM Assessment. The Minnesota IPM Assessment covers all major agronomic crops in Southern MN and includes questions on general agronomics, weed management, insect management and disease management. The IPM assessment was conducted in 2003, 2004, 2005, and 2006 at Private Pesticide Applicator Training (PPAT) meetings in Southern Minnesota. A total of 1727 assessments have been completed with 150, 415, 440, and 722 private applicators completing the assessment in 2003, 2004, 2005, and 2006 respectively. The farmers attending the PPAT meetings completed the self assessment at the beginning of the session and various IPM topics were covered during the remainder of the meeting. Results from the assessments were compiled and analyzed to expose opportunities for increased IPM adoption, and to help educators develop programs that would assist farmers in implementing more IPM practices. When participants were asked about their weed control philosophy 15 to 20 percent of growers were resolved to complete weed control, while 40 to 50 percent of growers wanted to achieve a high level of weed control while tolerating some weed escapes, and only 25 to 45 percent believed in weed control with the greatest net return. Another example is that only 70 percent of growers scout all of their fields for weeds, and only 50 percent of growers scout their fields 7-14 days after a postemergence herbicide application. From the 2006 assessment 77 percent of growers are planting Roundup Ready or Roundup Ready/Liberty Link stacked corn hybrids, and 86 percent of growers planted Round Ready or Roundup Ready/STS stacked soybean varieties. Also in the 2006 survey growers listed their most problematic broadleaf weeds as common lambsquarters (43%), giant ragweed (36%), waterhemp species (35%), velvetleaf (29%), common ragweed (21%), and pigweed species (12%). IPM assessment summaries demonstrated opportunities for additional educational programming due to the incomplete adoption of IPM tactics.

APPLYING HERBICIDES SAFELY AND LEGALLY. Roger A. Flashinski, Program Manager, Pesticide Applicator Training, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

This presentation will review the legal aspects of applying herbicides to control invasive species in a natural communities environment. Are private landowners regulated? What type of applicator am I? Do volunteers need to become certified applicators? Is direct supervision allowed? Although some of the discussion on the legal use of pesticides will be generic for all NCR states, most will be Wisconsin specific. Also, I will briefly discuss the toxicity classification of pesticides, the significance of signal words, personal protective equipment requirements, how we can reduce exposure, and how an applicator can unknowingly expose himself or herself and others when handling pesticides.

APPLYING HERBICIDES EFFECTIVELY AND ACCURATELY. David W. Fischer, Associate Professor, Dane County Crops and Soils Agent, University of Wisconsin – Extension, Madison, WI 53718.

Herbicides can be an effective tool for the management and control of invasive weeds. However, to maximize product effectiveness, several factors need to be better understood by those applying and recommending herbicides in invasive plant settings. These can include a full understanding of the target plant, application equipment, and control options.

Many volunteers have at least a basic understanding of the plants they are charged to control. However, understanding how these characteristics interact with herbicide control is sometimes more limited. Herbicide application timing as it relates to life cycle is possibly the most important aspect. Garlic mustard *Alliaria petiolata* (Bieb.) Cavara & Grande produces seed very early in the growing season, yet I have seen herbicide applications being made to plants already setting seed as well as fielding phone calls with questions about using herbicides to control garlic mustard after seed set has begun. These applications will do very little to control the infestation. In contrast, herbicide applications made in winter to green plants may result in near complete control of seed production for the following season while almost eliminating risk to desirable species found at the application site.

Accuracy of herbicide applications weighs heavily on a strong understanding of spray equipment and label recommendations. In some situations, applicators may be able to use sprayers mounted on all terrain vehicles (ATV) and make an application with rates based on a per acre basis. This requires that applicators calibrate the sprayer to deliver a known rate. The easiest method to determine spray rate is as follows. 1) Measure the distance in inches between spray nozzles; 2) divide 8160 by the number from step 1. This represents the distance in feet to be traveled in a timed run. 3) Drive the ATV with the tank at least ½ full of water only at spraying speed the distance determined from step 2 recording in seconds how long it takes. 4) Operate the sprayer collecting output from several nozzles for the time determined from step 3. 5) Measure the output collected from nozzles in **ounces** and determine the average. 6) Take ½ of the output from step 5 (or divide by 2). This is the output in gallons per acre for the ATV mounted sprayer.

Sprayers setup to use one adjustable nozzle, either a backpack sprayer, hand pump, or CO_2 sprayer typically apply materials on a spray to wet or spray to runoff basis, depending on label recommendations. While each person will decide for himself or herself what spray to wet or spray to runoff means, control of sprayed plants is rarely affected by spray volume. To insure the proper amount of herbicide formulation is added to the spray tank, applicators must know the size of the spray tank. Below is a simple chart to help mix various common rates to tanks ½ to 2 ½ gallons in size.

Desired Volume	Amount of product					
	½%	1%	1 ½%	2%	5%	10%
½ gal	1/3 oz	2/3 oz	1 oz	1 1/3 oz	3 ¼ oz	6 ½ oz
1 gal	2/3 oz	1 1/3 oz	2 oz	2 2/3 oz	6 ½ oz	1 ½ cups
1 ½ gal	1 oz	2 oz	3 oz	4 oz	1 ½ cups	1 ¼ pints
2 gal	1 1/3 oz	2 2/3 oz	4 oz	5 1/3 oz	1 2/3 cups	1 2/3 pints
2 ½ gal	1 2/3 oz	3 1/3 oz	5 oz	6 2/3 oz	1 pint	2 pints

The question than becomes what product can be used. This afternoon's speaker will go into the specifics on that topic and I will defer to both their presentation and abstract for the specifics. Each situation may have several viable options for use. No matter what product is used, applications must follow label directions. One website I have used to help consumers look at labels prior to purchasing the product is www.cdms.net.

Finally, I must discuss what has been referred to as the glyphosate saga. Once glyphosate came off patent, multiple glyphosate containing products were introduced. In an attempt to make the process easier, several organizations released publications recommending mixing rates based on percent active ingredient of the final mix. This has further confused the process and in fact results in rates that exceed maximum labeled rates – a direct violation of FEDERAL law. Unfortunately, these mixing recommendations have taken hold and we must now educate all users of finding the proper rate on the label and mixing accordingly. Because glyphosate is marketed in concentrations from ready to use containing 1 to 2% a.i. to concentrations exceeding 50% a.i., organizations fear removing the a.i. instructions will result in those ready to spray products being further diluted. Marketing personnel for the producers have worked hard to have the consumer understand they are purchasing a ready to use product not to be further diluted. In addition, labels on store shelf products rarely exceed 6 pages and have tables showing the number of ounces or tablespoons to add to one gallon of water to obtain the desired final concentration.

Herbicides can become an extremely effective and cheap method of control for invasive species. However, work needs to be done to insure applications are made both accurately as well as effectively. Proper timing and rate will be an excellent companion to hand removal of invasive species and can prevent damage to desirable species present in the site.

MATCHING NEEDS WITH PRODUCTS: ROLE OF HERBICIDES IN INVASIVE PLANT MANAGEMENT. Robert A. Masters, Rangeland Scientist, and Byron B. Sleugh, Forage Agronomist, Dow AgroSciences, Indianapolis, IN 46268

Invasive plants impede grassland restoration by disrupting ecosystem processes. Managing invasive plants requires manipulating disturbance regimes that favor desirable species and wanted changes in successional trajectories. Reasons for the arrival, establishment, and spread of invasive plants should be understood before effective grassland restoration strategies are developed. Removing an invasive plant species without attention to plant community dynamics often only opens niches for other undesirable species to occupy. Restoration of desirable plant communities that resist invasion is an appropriate goal for grassland restoration programs. The integrated weed management paradigm provides a context for managing invasive plants that focuses on ecosystem processes and not on particular plant species or control practices. Prevention, detection, and control are key components of integrated management strategies. The suitability of weed control tools (biological, chemical, mechanical, and cultural) will vary according to the invasive plant and invaded site characteristics. The merits of each control measure and the potential for complementary or synergistic interactions when applying measures in appropriate sequences and combinations should be considered when developing grassland restoration programs. Herbicides can serve as catalysts to expedite vegetation change, which leads to development of desired plant communities. The variety of herbicides currently available, with different modes of action and selectivity, and readily available precise and accurate application technologies provide land managers with many options to selectively alter plant composition, manage plant community succession, and accelerate grassland restoration.

LINKING QUESTIONS TO ANSWERS: IMPROVING COMMUNICATION AMONG RESEARCHERS, LAND MANAGERS, AND EXTENSION PERSONNEL. John Cardina and Mark J. Renz, Associate Professor, Department of Horticulture and Crop Science, Wooster, OH 44691, and Assistant Professor, Department of Agronomy, University of Wisconsin-Madison, Madison, WI 53706.

Effective invasive plant management involves a wide range of people and organizations. While much research has been conducted on invasive plant biology and invaded site characteristics, many times this information is not delivered or applicable to the land managers and private landowners. The purpose of this session is to discuss why this occurs and how communication between researchers, land managers and extension personnel can be improved. Survey results showed that although researchers and land managers believe cooperation is important for addressing invasive plant issues, communication between the two groups is lacking. Researchers tended to communicate most frequently with other researchers, and land managers communicated with other land managers to solve invasive plant problems. Responders indicated that interactions were limited by time and funding constraints rather than by lack of knowledge or interest. Specific examples of research that involves the participation of the land managers in the development of research projects will be presented along with an explanation of how obstacles were overcome in completing the project.

A ROUND TABLE DISCUSSION ABOUT HERBICIDE ALTERNATIVES. David G. Borneman, Lisa A. Brush, Roger C. Anderson, Mary Blackmore, Ray W. Newman, John T. Walkowiak; Manager, Natural Area Preservation Division, City of Ann Arbor, 1831 Traver Road, Ann Arbor, MI 48105; Executive Director, The Stewardship Network, 416 Longshore Drive, Ann Arbor, MI 48105; Professor, Illinois State University, Campus Box 4120, Normal, IL 61790; Researcher, Northwest Illinois Audubon Society, 9024 W. Grove Road, Forreston, IL 61030; Forest Plant Ecologist, Chippewa National Forest, Cass Lake, MN 56633; Forestry Bureau Chief, Iowa Department of Natural Resources - Forestry, Wallace State Office Building, Des Moines, IA 50319

What's the best way to control invasive species in natural areas? For a growing number of land managers, the answer frequently involves the use of herbicides, as demonstrated by a large number of talks at this symposium. But before you reach for the herbicide bottle, have you fully considered what other alternatives might be available? In this round-table discussion, we'll hear about several other strategies being employed by land managers across the Midwest. These include prescribed fire, grazing, mechanical control, manipulating inorganic soil nutrients, mycorrhizae, people power, and a variety of other "minimally toxic weed control methods." The session will begin with each speaker spending a few minutes reporting on their own experiences with some of these alternative methods. Following that, we'll have a facilitated round-table discussion about the pros and cons of these and other alternatives, the importance of timing, and how any of these strategies can be made more effective in combination with other methods. We'll consider how these strategies may or may not fit into your comprehensive strategy to control invasive species in your natural areas, whether or not you choose to complement them with herbicides.

NEW INVASIVE TREES AND SHRUBS IN THE MIDWEST. Debbie Maurer, Restoration Ecologist, Lake County Forest Preserves, Grayslake, IL 60030, Kelly Kearns, Plant Conservation Program Manager, Wisconsin Department of Natural Resources, 101 S. Webster St., Madison, WI 53707, Jennifer Hillmer, Land Steward, The Holden Arboretum, 9500 Sperry Road, Kirtland, OH, 44094

Several species of trees and shrubs which are invasive in other regions of the country are beginning to invade the Midwest. Together we can reduce the impacts of these new invaders by alerting land managers and others to these species and conducting early detection and eradication or containment. This presentation will cover the current and potential range, ecology, identifying characteristics, potential impacts and unique control methods of several trees and shrubs that are likely to expand their range and impacts in the Midwest. Species covered will include Tree-of-heaven (*Ailanthus altissima*), Amur Honeysuckle (*Lonicera maackii*), Privets (*Ligustrum* species), Japanese Barberry (*Berberis thunbergii*), Royal Paulownia (*Paulownia tomentosa*), Sawtooth Oak (*Quercus acutissima*), Callery Pear (*Pyrus calleryana*), and others.

NEW INVADERS: STATUS OF SOME NON-NATIVE INVASIVE VINES IN THE MIDWEST.
Jody P. Shimp, Regional Administrator, Illinois Department of Natural Resources, Division of Natural Heritage, 11731 State Hwy. 37 Benton, IL 62812.

Exotic species invasions and their cumulative impacts are having profound environmental consequences on Midwestern natural communities. Exotic plant species threaten every aspect of ecosystem health and productivity on public and private lands. This exotic invasion on the Midwest and its communities is resulting in a gradual loss of biodiversity. Exotic vines are some of the most troublesome invaders because they tend to form the most dense infestations. Invasive vines get established in forest gaps where they can collapse and smother nearby vegetation preventing the natural regeneration process. Often times they are hard to control because of the shear biomass. Japanese honeysuckle (*Lonicera japonica*), Chinese yam (*Dioscorea oppositifolia*), kudzu (*Pueraria lobata*), round-leaved bittersweet (*Celastrus orbiculatus*), Japanese Hops (*Humulus japonicus*), Mile-a-minute Weed (*Polygonum perfoliatum*), climbing Euonymus (*Euonymus fortunei*) and Black swallow-wort (*Vincetoxicum nigrum, syn. Cynanchum nigrum*) are among some of the invasive exotic vines which pose a serious threat to Midwestern natural communities.

For example, in some parts of the Midwest, Japanese honeysuckle is so wide spread and common in forests that any control effort is generally limited to sensitive communities or rare plant sites. Chinese yam is a highly invasive but little understood deep rooted, herbaceous, perennial vine native to Asia. In the Midwest, Chinese yam is primarily confined to the southern counties. In the Midwest, most of the populations of kudzu are located in the southernmost counties of Missouri, Illinois and Indiana however, populations are scattered in other parts of those states and extend as far north as Chicago. Round-leaved bittersweet is another Asiatic vine which certainly has the characteristics of a highly invasive plant species - high reproductive rate, rapid growth rate, long range dispersal, broad photosynthetic range, and root suckering abilities. Round-leaved bittersweet is scattered in the Midwest and in areas where it is established it is a real problem.

Many of these invasive vines pose resource management challenges. This presentation will touch on key identification features; distribution; life history, ecological significance; and notes on control for the invasive vines mentioned above.

BIOLOGY OF MULTIFLORA ROSE. Jerry D. Doll, Weed Scientist Emeritus, University of Wisconsin, Department of Agronomy, Madison, WI 53706.

While native to eastern Asia (Korea, Japan and China), multiflora rose (*Rosa multiflora*) is certainly adapted to many North American habitats. Introduced in the late 1800s for use as an ornamental rose root stock and promoted in the 1930s through 1950s for conservation and wildlife benefits and as a living fence ("horse high, bull tough and hog tight"). West Virginia planted more than 14 million multiflora rose plants in the 1940s to 1960s (Dugan, 1960). The original plantings soon gave rise to seeds that were disseminated well beyond these sites. Estimates are that multiflora rose now infests more than 45 million acres in the eastern half of the USA (Loux et al. 2005). Nearly every state with multiflora rose is now working to contain this weed and regain infested land. Understanding the biology of this plant is important in developing prevention, management and control strategies.

Plant description

The easiest way to distinguish multiflora rose from nearly all the wild roses is its large size and the fact that it is one of the "thorniest" of roses. The canes of multiflora rose arise from the root crown and are generally vertical until they are 4 to 5 feet tall at which time they become arching or trailing. Plants in full sunlight may reach heights of 8 to 10 feet and in shaded conditions, canes can grow through and on other trees to lengths in excess of 20 feet. The tips of some canes may touch the soil and under certain conditions roots may form. Stems are flexible, green to reddish with many recurved thorns with a wide base that tear flesh and clothing mercilessly. Multiflora rose leaves are pinnately compound with 5 to 11 leaflets. Prominent and fringed stipules are found at the base of the leaf petiole.

Flowering occurs from late May to June and pollination is accomplished by insects. The inflorescence has 25 to 100 flowers borne in terminal clusters (hence both the common and specific names of "multiflora"). Flowers are fragrant with five white to whitish-pink petals. The pistils form single-seeded achenes with hard seed coats that are resistant to damage. The fleshy, berry-like fruits (known as hips, the aggregate fruits of the rose plant) become bright red. Hips do not split open to release seeds but become leathery and uneaten hips often remain on bushes through the winter.

Habitat and habit

Multiflora rose is adapted to many nondisturbed habitats including hillside pastures, fence rows, right-of-ways, stream banks, recreational lands, Conservation Reserve fields, edges of woods and thin woodlots, especially grazed woodlots. Multiflora rose seems particularly adapted to steep hillsides. Infestations are found in most states except in the Rocky Mountain region with the most serious problems from the Corn Belt to the eastern seaboard. Perhaps the only condition plants do not tolerate is flooding. Plants thrive in full sunlight and endure shade. Multiflora rose is described as moderately winter hardy (USDA hardiness zones 5 to 8) and indeed cold winters kill some plants in northern regions, defeating the purpose of plantings made as living fences.

Multiflora rose grows as isolated plants (particularly in open areas) and as dense, impenetrable thickets, especially on sloping sites and in partially shaded areas. Unless killed by human or natural means, plants live indefinitely. No data were found on how long individual multiflora rose bushes might live.

Seed biology

Each multiflora rose hip contains 7 to 8 seeds [1 to 22 seeds each in W. Virginia (Amrine, 2002) and 5 to 11 seeds each in Wisconsin (Doll, unpublished data), respectively]. Robust multiflora rose bushes in the southeastern region of the USA form an average of 50 panicles (flower clusters) per cane; each panicle has with nearly 50 fruits each with seven seeds, potentially resulting in 17,500 seeds per cane and up to 500,000 seeds per plant (Amrine, 2002). In Wisconsin, multiflora rose is less prolific in flowering as not all canes flower each year (Doll, personal observation) but more than a sufficient "seed crop" is produced to propagate the species within and well beyond currently infested locations.

Single multiflora rose seeds weigh 6 to 9 mg resulting in 50,000 to 80,000 seeds per pound (Meyer, 2006) Meyer also states that the germination of rose seeds in general is a "complex process that may involve changes at the pericarp, testa and embryo levels. The degree of dormancy and the principal level of dormancy control vary among species, cultivars, seedlots, and even among hips within a single bush." Stratification (chilling of seeds under moist conditions) may stimulate fresh seeds to germinate. The Association of Official Seed Analysts (1993) suggests that storing seeds in a wet medium at 3 to 5 C for 28 days induces germination but much longer periods (90 to 180 days) were cited by Meyer (2006). My efforts to germinate multiflora rose seeds were not rigorous (seeds kept at room temperature or refrigerated for 1 to 5 months) but completely failed to achieve germination (Doll, unpublished data). Cold stratification from Feb. 1 to April was recommended by Steavenson (1946) to enhance germination. Under natural conditions, it would seem that a single winter season would be sufficient to break multiflora rose seed dormancy.

No data on seed longevity in either storage or natural conditions were found. Several authors note that seeds can live for many years and some state that seeds can last for 20 years in the soil. Longevity and germination studies under field conditions are needed.

The fruits (hips) of multiflora rose offer wildlife benefits. They are consumed by many bird species, particularly American robins and cedar waxwings but also by grouse, pheasants, wild turkeys, (Evans, 1983; White and Stiles, 1992). Mice, rabbits, white-tail deer, chipmunks and other animals also eat multiflora rose hips, especially in the winter when other food sources are scarce. Seed consumption by animal inevitably leads to seed dissemination and "instant fertilization" as they pass through and leave the digestive system. The tough seed coat of multiflora rose seeds is somewhat scarified as sees pass through the digestive tract of birds, promoting seed germination (Wyman 1940; Lincoln, 1978). Multiflora rose fruits contain 9.2% crude protein, 4.2% crude fat and 4.4 kcal/g of gross energy (Dekker et al. 1991). Fruits are rich in carotene and ascorbic acid and both fruits and seed can be used as a laxative and diuretic (Duke and Ayensu, 1985).

Multiflora rose seedlings grow inconspicuously for the first year or two (Schery 1977) but quickly become well anchored. Once established, it is difficult to dislodge plants by pulling as stems usually break off, leaving the root crown in tact and capable of resprouting.

Root survival

As with all perennial species, multiflora rose longevity requires the accumulation and storage of sufficient quantities of carbohydrates to survive winter. No data on root carbohydrate levels under natural or managed conditions were found. In particular, the impact of defoliation by mowing, burning or other means on root reserves needs to be studied. These practices, alone or in combination, may weaken multiflora rose plants sufficiently so that they do not survive winter. Trials in West Virginia found that mowing bushes to a 3-inch height and then repeatedly cutting them back to this height at 2- and 4-week intervals killed most plants at the end of two years (Bryan and Mills, 1988). Subsequent studies compared 4- and 8-week defoliations during the entire growing season for 2 years. At the start of the second year, 21% of the plants were dead and at the start of the fourth season, 94% were dead. Interestingly, small multiflora rose plants survived the longest. Plant kill did not differ between defoliation frequencies so if defoliation via mowing or close animal grazing could be done at least three or four times annually for at least 3 years, many multiflora rose plants would be killed (Bryan 1994).

Infrequent mowing of multiflora rose seldom kills plants but if done before viable seeds are formed, even a single mowing would greatly reduce seed production. Unfortunately, many infestations are on sites that are difficult at best to mow.

Burning studies in Texas on a native rose species found that burning alone reduced the plant's biomass but did not eradicate it (Gordon and Scifres, 1977). Burning gave more than 90% topkill of McCartney rose; however regrowth began within 2 weeks of burning with an average cane elongation of nearly 2 inches a month resulting in canopy cover replacement of 10 to 15% per month. They recommend a practice we are seeing in Wisconsin, namely using fire 12 to 18 months after applying herbicide to destroy the dead canes and rejuvenate grasses

Multiflora rose may form new plants via layering of the stems (stems root when in contact with the soil). However, this is not a common phenomenon. Some believe that multiflora rose has a spreading root system. This is not true. Nevertheless, multiple stems arise from the root crown and to ensure that no regrowth occurs when plants are physically removed from the soil, the entire root crown must be excavated. This usually means digging to remove roots to at least a 6- to 8-inch depth.

References cited

J. W. Amrine, Jr. Multiflora rose. In: Van Driesche, R., *et al*., 2002, Biological Control of Invasive Plants in the Eastern United States, USDA Forest Service Publication FHTET-2002-04, 413 p. On the web at: http://www.invasive.org/eastern/biocontrol/22MultifloraRose.html.

Bryan, W.B. and T.A. Milles. 1988. Effect of frequency and method of defoliation and plant size on survival of multiflora rose. Biological Agriculture and Horticulture 5: 209-214.

Bryan, W.B. 1994. Mechanical control of the multiflora rose. West Virginia Univ. Exten. Ser. Fact Sheet. Available at: http://www.caf.wvu.edu/~forage/5420.htm

Decker, Scott R.; Pekins, Peter J.; Mautz, William W. 1991. Nutritional evaluation of winter foods of wild turkeys. Canadian Journal of Zoology. 69: 2128-2132.

Dugan, R. F. 1960. Multiflora rose in West Virginia. West Virginia Univ. Agric. Expmt. Sta. Misc. Bull. 447, Morgantown, West Virginia.

Duke, J.A. and E.S. Ayensu. 1985. Medicinal Plants of China. 705 pp. Reference Publications, Box 344, Algonac, Michigan.

Evans, J.E. 1983. A literature review of management practices for multiflora rose (Rosa multiflora). Natural Areas Journal. 3: 6-15.

Gordon, R.A. and C.J. Scifres. 1977. Burning for improvement of McCartney rose-infested coastal prairie. Texas Agricultural Experimental Station B-1183. 15 p.

Lincoln, Jr., W. C. 1978. The effect of the digestive tract on the germination of multiflora rose seed. Newsletter of the Association of Official Seed Analysts 52: 23.

Loux, M.M., J.F. Underwood, J.W. Amrine Jr., W.B. Bryan and R. Chandran. 2005. Multiflora rose control. Ohio State Univ. Ext. Bull. 857. 16 p.

Myer, Susan E. 2006 (?). *Rosa* L. at this web site: www.nsl.fs.fed.us/wpsm/Rosa.pdf

Schery, R. 1977. The curious double life of *Rosa multiflora*. Horticulture 55: 56-61.

Steavenson, H.A. 1946. Multiflora rose for farm hedges. Journal Wildlife Management 10: 227-234.

White, Douglas W.; Stiles, Edmund W. 1992. Bird dispersal of fruits of species introduced into eastern North America. Canadian Journal of Botany. 70: 1689-1696.

Wyman, D. 1949. Shrubs and vines for American gardens. Macmillan Company, N.Y. 1st Edition. 442 pp.

Helpful web sites

http://plants.usda.gov/

http://www.fs.fed.us/database/feis/plants/shrub/rosmul/management_considerations.html

HERBICIDE RECOMMENDATIONS FOR CONTROL OF MULTIFLORA ROSE. Mark M. Loux, Professor, Dept. of Horticulture and Crop Science, The Ohio State Univ., Columbus, OH 43210.

Weed scientists and agronomists at a number of universities have conducted research on the control of multiflora rose with herbicides. Although there is not a plethora of information on management of multiflora rose, results of these studies and recommendations for control have been reported in newsletter articles and other extension publications. Extensive research on chemical control was conducted by The Ohio State University between 1971 and 1995. The results of these studies, along with applicable research from other states, was the basis for one of the more comprehensive publications on this subject, OSU Extension Bulletin 857, "Multiflora Rose Control", which was recently updated and reprinted. This publication also contains information on control with grazing and mowing, along with a summary of current knowledge on biological agents that infest multiflora rose. A search of the World Wide Web using "multiflora rose control" as the search phrase turns up most of the relevant information, including the following: "Mulitflora Rose and its Control" – Iowa State University; "Long-term Strategies to Control Multiflora Rose – University of Wisconsin; "Control of Autumn Olive, Multiflora Rose, and Tartarian Honeysuckle: Chemical Information" – West Virginia University/NRCS; and "Multiflora Rose Management in grass Pastures" – Penn State University.

Multiflora rose can be effectively controlled with a variety of application methods and herbicides, and it can be accomplished in the spring, summer, or winter. The choice of application method should be based on the type of situation (pasture, ditchbank, noncrop, etc), topography, the population density of the multiflora rose, and seasonal labor availability. For example, a dense infestation of relatively small multiflora rose in a fencerow might be treated with a foliar application of herbicide in the late spring or summer, especially where the topography allows use of a tractor or ATV-mounted sprayer. Conversely, a less dense infestation of well-established plants on a hillside might be controlled with basal bark treatments in the winter. To prevent herbicide from contaminating water, plants adjacent to water can be cut and the stumps immediately treated with herbicide. The most effective long-term control often involves a combination of chemical and mechanical control. It is essential to implement annual control measures to prevent reinfestation by seedlings and retreat plants that survive prior herbicide treatment.

The most effective herbicides for foliar application to multiflora rose include glyphosate, imazapyr, and metsulfuron methyl, which can be applied between leafout in spring through the onset of leaf senescence in the fall. Several other herbicides can be effective if applied by June, and these include dicamba, and commercially available mixtures of triclopyr plus 2,4-D, dicamba plus 2,4-D plus 2,4-DP, and picloram plus 2,4-D. Herbicide products that contain growth regulator herbicides (dicamba, triclopyr, picloram) can be more effective when applied as basal bark treatments compared with foliar application. Basal bark treatments are applied during the winter to dormant plants. Kerosene or diesel fuel is typically included in the spray mix to facilitate herbicide movement through the bark. Herbicides that are effective in basal bark treatments include dicamba, and commercially available mixtures of triclopyr plus 2,4-D, dicamba plus 2,4-D plus 2,4-DP.

Dicamba and metsulfuron methyl are effective when applied as a spot concentrate to the soil area within about 20 cm of plant crowns. Spot concentrate treatments should be applied in winter when plants are dormant. Application of tebuthiuron pellets to the soil around multiflora rose plants is also effective, primarily when applied in the winter months, although control of plants may not be immediately evident. Tebuthiuron will kill most other vegetation in the treated area. Research at Purdue University showed effective control from application of herbicide directly to the cut stumps of large plants. Herbicide products labeled for cut stump application and containing imazapyr, triclopyr, and picloram are suitable for this application method. A number of these products are formulated and packaged for application directly to cut stumps, without further dilution.

MANAGEMENT OF MULTIFLORA ROSE IN WEST VIRGINIA WITH GRAZING AND HERBICIDES. Rakesh S. Chandran and William B. Bryan. Associate Professor and Extension Weed Specialist, and Professor, Division of Plant and Soil Sciences and Extension Service – Agriculture and Natural Resources. West Virginia University, Morgantown, WV - 26506-6108.

Multiflora rose (*Rosa multiflora* Thunb.) is a troublesome weed encountered commonly in the hilly pastures of West Virginia. It is also gaining notoriety among fruit growers as a difficult-to-control weed. All counties in the state have reported instances of this troublesome weed. Along with autumn olive (*Elaeagnus umbellata* Thunb.), multiflora rose is difficult to manage using conventional control strategies. Past studies have evaluated either sheep or goat in comparison to 2,4-D + triclopyr (Crossbow) to manage multiflora rose under power-line right of way. Goats reduced brush cover from 45% to 15% in 1 yr, while sheep took 3 yr to accomplish the same results. Cutting the brush helped grazing effectiveness, especially that of sheep. Costs incurred towards brush management was significantly lower when goats were used compared to other methods over the 5-yr period of the study. In a separate study, bushes were either clipped at 7.5 cm above soil or stripped at soil level mechanically at 2- or 4-wk intervals to evaluate regrowth. Stripped plants were killed after a 2-yr period while the clipped ones survived for 57 wk or more. Studies were also established in summer of 2006 determine the effectiveness of newer pasture herbicides like picloram+2,4-D (Grazon P+D), diflufenzopyr+dicamba (Overdrive), and aminopyralid+2,4-D (Forefront R&P) to control multiflora rose. All herbicides were determined to be effective (>80% control) when applied at labeled rates along with 0.5% methylated seed oil (MSO) at 1 mo after application. Regrowth will be assessed in 2007. A cost-share program involving small ruminants to manage and utilize pasture brushes was funded by Natural Resources Conservation Service (NRCS) in 2006. The project, which has a marketing component included, will involve 30 new growers to adopt and evaluate and these goat and/or sheep to reduce brush load in their pastures.

TACKLING MULTIFLORA ROSE AT A MULTI-COUNTY LEVEL WITH MULTIPLE STRATEGIES IN WISCONSIN. Steve Kohlstedt, Associate Professor, University of Wisconsin Extension, Richland County, Richland Center, Wisconsin 53581.

Southwestern Wisconsin has been seen multiflora rose thrive over the last thirty years to the point that it is in virtually every woodlot and pasture. In 2000, Extension Educators and Basin Educators in six counties in Southwestern Wisconsin organized regional multiflora rose educational events to build awareness of the severity of the problem and recommend different management measures. The regional meetings were held on three highly managed properties in Grant, Lafayette and Green Counties. These initial meetings focused on chemical demonstrations and cultural control measures, such as rotational grazing.

These regional field days sparked activities in all six counties nearly at once. All counties hosted educational field days and drew large audiences. They used the expertise of specialists to emphasize biology and management techniques for this invasive species.

Several counties even went further and established cost share programs for managing multiflora rose. This opened a new course for awareness and action. These counties built on the success of their landowners and hosted numerous field days highlighting these successes. The cost share programs allowed landowners to experiment with management ideas and share their successes and failures.

The cost share program became the catalyst for a strong network of landowners, who were willing to share their information, experiences and outcomes in network meetings within the counties where they live or own property. So small groups of 10 to 15 landowners would get together and share “how they are managing multiflora rose,” throughout the county.

As producers began to look at their wood lots more carefully, in Richland County, we found other opportunities for education and research. At one site, we discovered a strong infestation of Rose Rosette Disease. The site will be used to monitor the effects and spread of the disease. It will also provide a very unique opportunity to try different management techniques in conjunction with the disease. In the long run this site may provide insight to controlling multiflora rose with a combination of cultural techniques and a naturally occurring condition, rather than with chemicals. Only time and additional research will tell.

THE GARLIC MUSTARD BIOCONTROL STORY: PAST, PRESENT AND FUTURE.

Elizabeth J. Katovich, Esther Gerber, Hariet L. Hinz, Roger L. Becker, David W. Ragsdale, and Luke C. Skinner; Senior Scientist, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108, Research Scientist, CABI Bioscience, Delemont, Switzerland CH-2800, Senior Research Scientist, CABI Bioscience, Delemont, Switzerland CH-2800, Professor, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108, Professor, Department of Entomology, University of Minnesota, St. Paul, MN 55108, Invasive Species Program, Minnesota Department of Natural Resources, St. Paul, MN 55155.

The current status and development of a garlic mustard biological control program will be discussed. Four species of weevils, *Ceutorhynchus scrobicollis, Ceutorhynchus alliariae*, *Ceutorhynchus roberti*, and *Ceutorhynchus constrictus* are potential candidates for garlic mustard biological control in the United States. We will describe the biology and life cycle of each weevil species and how the release of a combination of weevil species may increase the effectiveness of biocontrol. In the United States, host range testing of potential biocontrol insects on non-target plant species is required prior to Federal (USDA-APHIS) approval for field release. We will describe the current status of the host range testing program, potential timeline for introduction, and current efforts in insect rearing in anticipation of field release.

MONITORING GARLIC MUSTARD POPULATIONS IN ANTICIPATION OF FUTURE BIOCONTROL RELEASE. Laura C. Van Riper, Luke C. Skinner, and Bernd Blossey, Research Associate, University of Minnesota, 411 Borlaug Hall, 1991 Upper Buford Circle, St. Paul, MN 55108, and Natural Resources Specialist Sr., MN Department of Natural Resources, 500 Lafayette Road, Box 25, St. Paul, MN 55155, and Associate Professor, Cornell University, 122E Fernow Hall, Ithaca, NY 14853.

Garlic mustard (*Alliaria petiolata*) is native to Europe, but has become invasive in forested regions throughout the United States. Garlic mustard is a concern because of its ability to invade high quality forests, form dense populations, and decrease abundance of native species. The evaluation of potential biocontrol agents may result in the availability of *Ceutorhynchus* weevils for biocontrol. Accurate and well-designed monitoring is essential to provide data as to the success of the biocontrol agents and the status of the ecosystem. Monitoring data can be used to determine if the target species has been reduced and if the native species are returning. Garlic mustard is a biennial and its populations can vary from year to year. Early monitoring is necessary to accurately characterize the population before biocontrol release. Two years of garlic mustard monitoring data from 12 sites has provided information about garlic mustard population dynamics, a characterization of the plant communities associated with garlic mustard, and a documentation of the low levels of herbivory currently found on garlic mustard in Minnesota (USA). Pre-release monitoring is an important component of biocontrol release.

SPRAY TANK ADDITIVES: WHY, WHEN, WHAT, and HOW TO USE THEM. Moe Finke and Rick S. Schulte, Territory Manager, UAP Distribution, DeForest, WI 53532

There are many different types of adjuvants used throughout agricultural, turf and ornamental and vegetation management fields concerning herbicides, insecticides fungicides and one size does not fit all. What maybe good for herbicides maybe bad for insecticides. These adjuvants range from; surfactants, penetrants, stickers, foamers, unfoamers, dyes, water conditioners, oils, etc. The adjuvant information is bases on independent laboratory studies conducted throughout the United States.

AGRILIANCE ADJUVANT UPDATE. Gregory K. Dahl, Joe V. Gednalske and Eric Spandl, Research Coordinator, Manager of Product Development and Agronomist, Agriliance LLC, St. Paul, MN 55164.

High surfactant oil concentrates are a recently recognized category of adjuvants. High surfactant oil concentrates are emulsifiable oil based products that contain 25 to 50 percent surfactant by weight in a minimum of 50% oil by weight. Agriliance has been manufacturing and selling high surfactant oil concentrates for the past few years. Currently high surfactant oil concentrates are used on approximately 14% of the acres treated with crop oil concentrates.

Agriliance has developed and will be marketing a high surfactant oil concentrate that uses methylated seed oil for the oil portion.

Field studies were conducted with nineteen herbicides such as nicosulfuron, nicosulfuron plus rimsulfuron, foramsulfuron, imazamox, clethodim, mesotrione, bentazon, atrazine, mesosulfuron and other herbicides applied at reduced rates with oil type adjuvants. The methylated seed oil based high surfactant oil concentrate was compared to current methylated seed oil adjuvants, petroleum based high surfactant oil concentrates and to crop oil concentrates, containing 17% emulsifier and 83% paraffinic oil. Crop oil concentrates and methylated seed oils were applied at labeled rates. The methylated seed oil and petroleum oil based high surfactant oil concentrates were applied at one-half of the rate of the methylated seed oils and crop oil concentrates.

Weed control was evaluated visually. Weed control with herbicides was similar when applied with methylated seed oil based high surfactant oil concentrates at one-half rates compared to methylated seed oil adjuvants applied at full rates. Methylated seed oils and methylated seed oil high surfactant oil concentrates provided equal or better weed control than petroleum based high surfactant oil concentrates or crop oil concentrates.

Field studies were conducted to evaluate the influence of adjuvants on control of glyphosate tolerant volunteer corn with glyphosate plus reduced rates of clethodim. Treatments included the herbicides alone and the herbicides with nonionic surfactant, crop oil concentrate, petroleum based high surfactant oil concentrate, methylated seed oil based high surfactant oil concentrates and methylated seed oil. In certain trials the previously listed adjuvants were applied without ammonium sulfate to determine the influence of the adjuvant alone. In most trials the adjuvants were applied with ammonium sulfate to improve weed control.

Treatments that contained an oil adjuvant system provided greater control of the glyphosate tolerant volunteer corn than treatments without oil adjuvants. The methylated seed oil high surfactant oil concentrate plus ammonium sulfate provided the greatest control of glyphosate tolerant corn. Some treatments that contained oil adjuvants such as traditional methylated seed oils provided less broadleaf weed control than treatments that did not contain oils. Methylated seed oil high surfactant oil concentrate plus ammonium sulfate adjuvant systems provided the best balance of glyphosate tolerant volunteer corn and broadleaf weed control of the adjuvant systems tested.

A modified vegetable oil plus emulsifier system has been developed that has increased canopy penetration, retention and reduced spray drift. The product has been compatible with most nozzle types and has performed well in ground and aerial applications.

The modified vegetable oil adjuvant reduced the percentage of fine droplets with most nozzle types without significantly increasing the percentage of very coarse droplets. This adjuvant has been used satisfactorily with nozzles that are incompatible with polymer type drift control adjuvants. The product has been used successfully on several million acres.

TANK-MIXING MICRONTRIENT FERTILIZERS, WATER CONDITIONERS, AND GLYPHOSATE FOR AN EFFICIENT SOLUTION. Mark L. Bernards, Donald Penner, and Jan Michael, Assistant Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE 68583-0915, and Professor and Research Technician, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824

Tank-mixing foliar micronutrient fertilizers with glyphosate may reduce weed control because of antagonistic cations present in the spray solution. This research 1) quantified the antagonism caused by various formulations of copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn), and 2) measured the extent that water conditioner adjuvants may prevent the antagonism from occurring. Most formulations of copper, iron, manganese, and zinc antagonized glyphosate efficacy on giant foxtail and velvetleaf. Formulations containing EDTA, HEDTA, or flavonol were the least antagonistic; those containing the sulfate salt or a lignosulfonic acid chelate were the most antagonistic. Tank-mixtures including the adjuvant NTANK overcame the antagonism more often than those containing ammonium sulfate (AMS) or Class Act Next Generation. Two micronutrient blends, one with (MC) and one without (MS) the chelates citric acid and EDTA, both reduced glyphosate efficacy on giant foxtail and velvetleaf. The addition of AMS or NTANK to these blends increased velvetleaf control, but neither adjuvant overcame the antagonism.

RECALCITRANT WEEDS IN OHIO VINEYARDS. Linjian Jiang, Tim Kock, Imed Dami, and Douglas J. Doohan, Graduate Student, Research Assistant, Assistant Professor and Associate professor, Department of Horticulture and Crop Science, The Ohio State University-Ohio Agriculture Research and Development Center, Wooster, OH 44691.

A survey was conducted to document the weeds that persisted in vineyards after weed control practices were complete. A particular interest was detection of weeds potential resistant to glyphosate. The survey was conducted throughout the state of Ohio by visiting 31 vineyards in 2004. Each grower provided us with an area ranging from 0.33 to several acres that they felt was representative of the general weed problems in the vineyards. Weed species and numbers were counted in 20 random drops of a 25×25 cm quadrat. Herbicide spraying history, grape varieties, vineyard locations, and grapevine age were collected by interviewing the growers and visiting the vineyards. Data were analyzed by SAS 9.1 using GLM model, and means were compared according to Student-Newman-Keuls (SNK) at the 0.05 level. Crabgrass, dandelion, pigweed, foxtail, fall panicum, clover, chickweed, common ragweed, smartweed, and oxalis were the most prevalent weeds in Ohio vineyards with relative abundance values of 44.2, 25.4, 17.7, 17.1, 14.3, 11.6, 11.3, 10.6, 10.3, and 9.3, respectively. When glyphosate was the sole means of weed control poor weed of crabgrass, dandelion, and oxalis was observed, relative to control with other herbicide management programs. These data suggest that glyphosate resistance may be a potential problem in these weeds. The survey also showed that weed problems were more severe in *Vinifera* vineyards than in Concord and French hybrid vineyards. *Vinifera* vineyards require hilling of soil around the base of the vines in autumn to protect the graft union from winter injury and mechanical removal of the soil hill in spring.

MIDWEST NATURAL RESOURCES GROUP ACTION PLAN FOR TERRESTRIAL INVASIVE SPECIES IN THE GREAT LAKES BASIN. Carmen T. Chapin, Midwest Natural Resources Group, National Park Service, Ashland, WI 54806.

In response to an inquiry from the federal Interagency Task Force for the Great Lakes Regional Collaboration on federal initiatives that could support the Great Lakes Regional Collaboration Strategy (http://www.epa.gov/greatlakes/collaboration/strategy.html), the Midwest Natural Resources Group (MNRG – http://www.mnrg.gov) developed this *Action Plan* to "… *apply [the MNRG's] existing resources to establish a team charged with developing an Action Plan, [and] to effectively coordinate and develop inventories, mapping and treatment of terrestrial invasive species for the Great Lakes basin."* This *Action Plan,* which closely parallels the 2001 National Management Plan written by the National Invasive Species Council, is a first step toward achieving this goal by promoting increased collaboration and efficiency among federal and non-federal partners within the basin. Through its action items, the plan also helps define the appropriate role of the MNRG in addressing the threat from terrestrial invasive species within the Great Lakes basin. To facilitate ongoing and effective leadership on invasive species control, the *Action Plan* calls for a permanent Great Lakes Terrestrial Invasive Species Committee (GL-TISC) to accomplish many of the action items in partnership with other federal, state, tribal and applicable non-governmental organizations (NGOs).