# Proceedings of the 68th Annual Meeting of the North Central Weed Science Society

## December 9-12, 2013
## Columbus, OH

This document contains the program and abstracts of the papers and posters presented at the annual meeting of the North Central Weed Science Society. Titles are arranged in the program by subject matter sections with the abstract number in parenthesis, abstracts are found in numerical order. Author and keyword indices are also included.

**Program**

# PROGRAM

## *General Session*

**Welcome: NCWSS, MIPN, and OIPC**

**Current Issues and Future Perspective: Update from CAST.** Phillip W. Stahlman*; Kansas State University, Hays, KS (97)

**WSSA EPA-Subject Matter Expert Position: My Initial Impressions.** Michael Barrett*; University of Kentucky, Lexington, KY (98)

**NCWSS Presidential Address.** Dave Johnson*; DuPont Pioneer, Johnston, IA (99)

**Necrology Report.** Kirk A. Howatt*; North Dakota State University, Fargo, ND (100)

## *Agronomic Crops*

**Common Windgrass Management in Winter Wheat.** Christy L. Sprague*; Michigan State University, East Lansing, MI (1)

**†Shattercane X ALS-Tolerant Sorghum F1 Hybrid and Shattercane Interference in ALS-Tolerant Sorghum.** Rodrigo Werle[1], Jared J. Schmidt[1], John Laborde[1], Angela M. Tran*[1], Cody F. Creech[2], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (2)

**Interactions Between Foliar Applied RyzUp SmartGrass Tank Mixed with Synthetic Auxin Herbicides in Corn.** Eric J. Ott*[1], James M. Wargo[2], John A. Pawlak[3]; [1]Valent USA Corporation, Greenfield, IN, [2]Valent USA Corporation, Atlanta, GA, [3]Valent USA Corporation, Lansing, MI (3)

**†Control of Glyphosate-Resistant Giant Ragweed by Tank Mixing Glufosinate with 2,4-D and/or Dicamba in Corn.** Zahoor A. Ganie*[1], Kevin Watteyne[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Bayer CropScience, Lincoln, NE (4)

**†Influence of Fall and Early Spring Application of Pre-packaged Tank Mixture of Iodosulfuron and Thiencarbazone-methyl on Control of Glyphosate-Resistant Giant Ragweed in No-till Corn.** Simranpreet Kaur*[1], Kevin Watteyne[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Bayer CropScience, Lincoln, NE (5)

**Control of HPPD-Resistant Waterhemp with Mesotrione and Tankmixes Applied Preemergence.** Jon E. Scott*[1], Aaron S. Franssen[2], Stevan Z. Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Syngenta Crop Protection, Seward, NE (6)

**Control of HPPD-Resistant Waterhemp in Corn and Soybean.** Jon E. Scott*[1], Aaron S. Franssen[2], Stevan Z. Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Syngenta Crop Protection, Seward, NE (7)

**†Weed Height and the Inclusion of Atrazine Influence Control of Multiple-Resistant Palmer Amaranth with HPPD-Inhibitors.** Jonathon R. Kohrt*, Christy L. Sprague; Michigan State University, East Lansing, MI (8)

*Presenter; † Student Contestant

**†Corn Yield as Influenced by Nitrogen Management, Residual Herbicide, and Other Pest Management Inputs.** John T. Buol*, Rebecca R. Bailey, Elizabeth J. Bosak, Tim Trower, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (9)

**†Cover Crop Response to Corn and Soybean Residual Herbicides.** Chris P. Corzatt*, Mark L. Bernards; Western Illinois University, Macomb, IL (10)

**Italian Ryegrass, *Lolium multiflorum* and Other Cover Crops for Suppression of Soybean Cyst Nematode, *Heterodera glycines*..** Bruce A. Ackley*, Steven K. Harrison, Mark Sulc; The Ohio State University, Columbus, OH (11)

**†Light Interception of Soybean as Influenced by Row Width, Seeding Rate, and Weed Competition.** Thomas R. Butts*[1], Jason K. Norsworthy[2], Greg R. Kruger[3], Lowell Sandell[4], Bryan G. Young[5], Kevin W. Bradley[6], Lawrence E. Steckel[7], Mark M. Loux[8], Vince M. Davis[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Arkansas, Fayetteville, AR, [3]University of Nebraska-Lincoln, North Platte, NE, [4]University of Nebraska-Lincoln, Lincoln, NE, [5]Southern Illinois University, Carbondale, IL, [6]University of Missouri, Columbia, MO, [7]University of Tennessee, Jackson, TN, [8]The Ohio State University, Columbus, OH (12)

**Weed Management with Flumioxazin+Pyroxasulfone in Soybean.** Nader Soltani*, Christy Shropshire, Peter H. Sikkema; University of Guelph-Ridgetown, Ridgetown, ON (13)

**The Influence of Herbicide Rate and Application Timing on the Soil-Residual Efficacy of Preplant Soybean Herbicides.** R. Joseph Wuerffel*[1], Bryan G. Young[1], Julie M. Young[1], Mark L. Bernards[2], Aaron G. Hager[3]; [1]Southern Illinois University, Carbondale, IL, [2]Western Illinois University, Macomb, IL, [3]University of Illinois, Urbana-Champaign, IL (14)

**†Optimum Glyphosate Application Timing in Soybean as Influenced by Preemergence Residual Herbicide Use Following Different Planting Dates.** Ryan P. DeWerff*, Vince M. Davis, Shawn P. Conley; University of Wisconsin-Madison, Madison, WI (15)

**†Control of Glyphosate-resistant Common Waterhemp with Long Chain Fatty Acid Inhibitors Applied in a Split Application in Soybeans.** Debalin Sarangi*[1], Lowell Sandell[1], Stevan Z. Knezevic[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE (16)

**Dicamba in a Residual System for Glyphosate-Resistant Waterhemp Control in Soybean.** Seth T. Logan*[1], Bryan G. Young[2], Julie M. Young[2], Simone Seifert-Higgins[3], Sara M. Allen[4]; [1]Monsanto, Tamaroa, IL, [2]Southern Illinois University, Carbondale, IL, [3]Monsanto Company, St. Louis, MO, [4]Monsanto, Bonnie, IL (17)

**†Response of Glyphosate-resistant Horseweed to POST Herbicides.** Joseph D. Bolte*, Reid J. Smeda; University of Missouri, Columbia, MO (18)

**Enlist Soybean Tolerance to Enlist Duo.** Jeff M. Ellis*[1], David C. Ruen[2], Eric F. Scherder[3], David M. Simpson[4], Scott C. Ditmarsen[5]; [1]Dow AgroSciences, Smithville, MO, [2]Dow AgroSciences, Lanesboro, MN, [3]Dow AgroSciences, Huxley, IA, [4]Dow AgroSciences, Indianapolis, IN, [5]Dow AgroSciences, Madison, WI (19)

**Palmer Amaranth Control Program in Enlist Soybean.** Kristin Rosenbaum*[1], Jeff M. Ellis[2], Brad Hopkins[3], Jonathan Siebert[4]; [1]Dow AgroSciences LLC., Lincoln, NE, [2]Dow AgroSciences, Smithville, MO, [3]Dow AgroSciences LLC., Indianapolis, IN, [4]Dow AgroSciences, Leland, MS (20)

**In-Season Weed Control in Dicamba-Resistant Soybean Systems for Controlling Glyphosate Resistant and Other Tough to Control Weeds.** Jeffrey Golus*[1], Lowell Sandell[2], Amit J. Jhala[2], Ryan S. Henry[1], Mayank Malik[3], Simone Seifert-Higgins[4], Tony D. White[4], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]Monsanto, Lincoln, NE, [4]Monsanto Company, St. Louis, MO (21)

*Presenter; † Student Contestant

**BAS 18322H for Glyphosate Resistant Waterhemp Control in Dicamba-Tolerant Soybean.** Stevan Z. Knezevic[1], Jon E. Scott[1], Leo D. Charvat*[2]; [1]University of Nebraska-Lincoln, Concord, NE, [2]BASF Corporation, Lincoln, NE (22)

**A197: A Technical Overview.** Stott Howard*[1], Gordon D. Vail[2], John P. Foresman[2]; [1]Syngenta Crop Protection, Des Moines, IA, [2]Syngenta Crop Protection, Greensboro, NC (23)

**†Control of Glyphosate-Resistant Volunteer Corn in Glufosinate-Resistant Soybeans.** Parminder S. Chahal*[1], Greg R. Kruger[2], Lowell Sandell[1], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (24)

**†Timing of Volunteer Corn Control Affects Sugarbeet Yield.** Amanda C. Harden*, Christy L. Sprague; Michigan State University, East Lansing, MI (25)

**Dry Bean Desiccation with Various Herbicides in Canada.** Nader Soltani*[1], Robert E. Blackshaw[2], Rob Gulden[3], Chris Gillard[1], Christy Shropshire[1], Peter H. Sikkema[1]; [1]University of Guelph-Ridgetown, Ridgetown, ON, [2]Agriculture Canada, Alberta, AB, [3]University of Manitoba, Manitoba, MB (26)

**The Effect of Growth Stage on Switchgrass Atrazine Tolerance.** Whitney M. Churchman*, Michael Barrett, David W. Williams; University of Kentucky, Lexington, KY (44)

**†Selection Based Improvement for 2,4-D Tolerance in Red Clover .** Tara L. Burke*, James Roberts, Norman Taylor, Michael Barrett; University of Kentucky, Lexington, KY (45)

**†Increased Soybean Seeding Rates Versus Preemergence Herbicide Use.** Ryan P. DeWerff*, Vince M. Davis, Shawn P. Conley; University of Wisconsin-Madison, Madison, WI (101)

**†Effect of Soybean Pre- and Post-Emergence Herbicides on Glyphosate, Glufosinate, and Imidazolinone Resistant Volunteer Corn.** Parminder S. Chahal*[1], Greg R. Kruger[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (102)

**†Control of Glyphosate-Resistant Giant Ragweed in Glufosinate- Resistant Soybean.** Simranpreet Kaur*, Lowell Sandell, Rodrigo Werle, Amit J. Jhala; University of Nebraska-Lincoln, Lincoln, NE (103)

**Control of Glyphosate-Resistant Giant Ragweed in Glyphosate-Tolerant No-till Soybeans.** Lowell Sandell*[1], Greg R. Kruger[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (104)

**†Influence of Soybean Seeding Rate, Row Spacing and Herbicide Programs on the Control of Resistant Waterhemp in Glufosinate-Resistant Soybean.** John Schultz*, Eric B. Riley, Jimmy D. Wait, Kevin W. Bradley; University of Missouri, Columbia, MO (105)

**†Multiple-Resistant Palmer Amaranth Control with Soil-Applied Herbicides in Michigan.** David Powell*, Christy L. Sprague; Michigan State University, East Lansing, MI (106)

**Effect of Herbicide and Application Timing on Residual Control of Horseweed Resistant to Glyphosate and ALS Inhibitors.** Bryan Reeb*, Mark M. Loux; The Ohio State University, Columbus, OH (107)

**Soybean Breeding Over the Last 80+ Years Has Improved Plant Branching and Reduced the Penalty for Low Seeding Rates.** Vince M. Davis*[1], Justin Suhre[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Illinois, Urbana-Champaign, IL (108)

*Presenter; † Student Contestant

**Harvest Aid Effects on Black Bean Desiccation and Yield.** Amanda M. Goffnett*, Christy L. Sprague;

Michigan State University, East Lansing, MI (109)

**†Effect of Tillage and Herbicides on Control of Glyphosate-Resistant Giant Ragweed in Corn and Soybeans.** Zahoor A. Ganie*, Lowell Sandell, Amit J. Jhala; University of Nebraska-Lincoln, Lincoln, NE (110)

**†Management of Palmer Amaranth in Corn Using Cover Crops and Herbicides.** Matthew S. Wiggins*, Lawrence E. Steckel; University of Tennessee, Jackson, TN (111)

**†Waterhemp and Palmer Amaranth Control Using Dicamba, 2,4-D and Isoxaflutole Based Chemical Programs.** Strahinja Stepanovic*[1], Lawrence E. Steckel[2], Jason K. Norsworthy[3], Bryan G. Young[4], Kevin W. Bradley[5], William G. Johnson[6], Mark M. Loux[7], Vince M. Davis[8], Thomas W. Eubank[9], Lowell Sandell[1], Greg R. Kruger[10]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Tennessee, Jackson, TN, [3]University of Arkansas, Fayetteville, AR, [4]Southern Illinois University, Carbondale, IL, [5]University of Missouri, Columbia, MO, [6]Purdue University, West Lafayette, IN, [7]The Ohio State University, Columbus, OH, [8]University of Wisconsin-Madison, Madison, WI, [9]Mississippi State University, Stoneville, MS, [10]University of Nebraska-Lincoln, North Platte, NE (112)

**The Effect of Growth Stage on Switchgrass Atrazine Tolerance.** Whitney M. Churchman*, Michael Barrett, David W. Williams; University of Kentucky, Lexington, KY (44)

**†Selection Based Improvemet for 2,4-D Tolerance in Red Clover .** Tara L. Burke*, James Roberts, Norman Taylor, Michael Barrett; University of Kentucky, Lexington, KY (45)

**Crop Response to Dicamba Applications on Soybean Event MON 87708.** Paul Feng*[1], Cindy L. Arnevik[1], Joe Cordes[2], Mindy Devries[3], Mark Lubbers[4], Debi Herren[2], Radha Mohanty[1]; [1]Monsanto Company, St. Louis, MO, [2]Monsanto Company, Jerseyville, IL, [3]Monsanto Company, Huxley, IA, [4]Monsanto Company, Witchita, KS (156)

**Dicamba Formulation Advancements.** Joseph J. Sandbrink*, Alison Macinnes, John W. Hemminghaus, Jeff N. Travers, Simone Seifert-Higgins, Susan E. Curvey; Monsanto Company, St. Louis, MO (157)

**Performance of Engenia™ Herbicide Programs in Dicamba Tolerant Soybeans.** Dustin Lewis*[1], John Frihauf[2], Walter Thomas[2], Steven Bowe[2], Luke L. Bozeman[2]; [1]BASF Corporation, Seymour, IL, [2]BASF Corporation, Research Triangle Park, NC (158)

**Stewardship of Engenia™ Herbicide.** Shane Hennigh*[1], Walter Thomas[2], Steven Bowe[2], Luke L. Bozeman[2]; [1]BASF Corporation, Story City, IA, [2]BASF Corporation, Research Triangle Park, NC (159)

**Enlist™ Soybean Tolerance and Weed Control with PRE Followed by POST Herbicide Programs.** David C. Ruen*[1], Jeff M. Ellis[2], David M. Simpson[3], Jonathan A. Huff[3]; [1]Dow AgroSciences, Lanesboro, MN, [2]Dow AgroSciences, Smithville, MO, [3]Dow AgroSciences, Indianapolis, IN (160)

**University Evaluation of Isoxaflutole Weed Management Programs in HPPD Tolerant Soybean System.** Michael L. Weber*; Bayer CropScience, Indianola, IA (161)

**Enhanced Weed Management Solutions with MGI Herbicide-Tolerant Soybeans.** Dain E. Bruns*[1], Rakesh Jain[2], Thomas H. Beckett[2], Brian L. Wilkinson[2], Brian Erdahl[2]; [1]Syngenta, Marysville, OH, [2]Syngenta, Greensboro, NC (162)

**Influence of Weed Competition Duration on Soybean Nutrient Acquisition and Grain Yield Characteristics.** Nick T. Harre*[1], Bryan G. Young[1], Scott E. Cully[2], Brett R. Miller[3], Mark Kitt[3], Bryan J. Ulmer[4]; [1]Southern Illinois University, Carbondale, IL, [2]Syngenta, Marion, IL, [3]Syngenta, Minnetonka, MN, [4]Syngenta, Basel, Switzerland (163)

*Presenter; † Student Contestant

**New Residual Management Systems to Address Herbicide Resistant Weeds in Soybeans.** Dario F. Narvaez*[1], James Whitehead[2], David Feist[3], Keith Miller[4], Dave Downing[5], Brian Ahrens[6]; [1]MANA, Wildwood, MO, [2]MANA, Oxford, MS, [3]MANA, Ft. Collins, CO, [4]MANA, Troy, IL, [5]MANA, Raleigh, NC, [6]MANA, Coralville, IA (164)

**Preemergence Weed Control in Soybean with Chlorimuron, Flumioxazin, and Metribuzin.** Kelly A. Barnett*[1], Helen A. Flanigan[2], Kevin L. Hahn[3], Dan Smith[4]; [1]DuPont Crop Protection, Whiteland, IN, [2]DuPont Crop Protection, Greenwood, IN, [3]DuPont Crop Protection, Bloomington, IL, [4]DuPont Crop Protection, Madison, MS (165)

**Bicyclopyrone, a New Herbicide for Improved Weed Control in Corn.** Gordon D. Vail*[1], Scott E. Cully[2], Ryan D. Lins[3], John P. Foresman[1]; [1]Syngenta Crop Protection, Greensboro, NC, [2]Syngenta, Marion, IL, [3]Syngenta, Byron, MN (203)

**Bicyclopyrone for Pre-emergence Weed Control in Corn.** Ryan D. Lins*[1], Thomas H. Beckett[2], Scott E. Cully[3], John P. Foresman[4], Gordon D. Vail[4]; [1]Syngenta, Byron, MN, [2]Syngenta, Greensboro, NC, [3]Syngenta, Marion, IL, [4]Syngenta Crop Protection, Greensboro, NC (204)

**Bicyclopyrone for Burndown and Post-Emergence Weed Control in Corn.** Scott E. Cully*[1], Thomas H. Beckett[2], Ryan D. Lins[3], John P. Foresman[4], Gordon D. Vail[4]; [1]Syngenta, Marion, IL, [2]Syngenta, Greensboro, NC, [3]Syngenta, Byron, MN, [4]Syngenta Crop Protection, Greensboro, NC (205)

**Dicamba + Cyprosulfamide Broadleaf Weed Control and Tolerance in Corn.** David Lamore*[1], Michael L. Weber[2], James R. Bloomberg[3]; [1]Bayer CropScience, Bryan, OH, [2]Bayer CropScience, Indianola, IA, [3]Bayer CropScience, RTP, NC (206)

**Enlist™ Corn Tolerance and Weed Control with PRE Followed by POST Herbicide Programs.** Joe Armstrong*[1], Michael Moechnig[2], Scott C. Ditmarsen[3], Mark A. Peterson[4]; [1]Dow AgroSciences, Davenport, IA, [2]Dow AgroSciences, Toronto, SD, [3]Dow AgroSciences, Madison, WI, [4]Dow AgroSciences, Indianapolis, IN (207)

**HPPD Resistant Palmer Amaranth Control with PRE and POST Applied Herbicides.** Curtis R. Thompson*, Dallas E. Peterson; Kansas State University, Manhattan, KS (208)

**Enhancement of the Weed Control of Preemergence Saflufenacil and Dimethenamid Applications with Various Post Emergence Timings and Rates of Pendimethalin in Grain Sorghum.** Randall S. Currie*[1], Curtis R. Thompson[2]; [1]Kansas State University, Garden City, KS, [2]Kansas State University, Manhattan, KS (209)

**Huskie Complete - Overview of Performance in Northern Plains Cereals.** Kevin B. Thorsness*[1], Steven R. King[2], Dean W. Maruska[2], Michael C. Smith[2], Charlie Hicks[3], George S. Simkins[2], Mark A. Wrucke[2]; [1]Bayer CropScience, Fargo, ND, [2]Bayer CropScience, Raleigh, NC, [3]Bayer CropScience, Fort Collins, CO (210)

**Kochia Control in Wheat with Pre- or Postemergence Herbicides.** Kirk A. Howatt*, Andrew N. Fillmore; North Dakota State University, Fargo, ND (211)

**Management Options for Control of Glyphosate Resistant Kochia in Fallow.** James R. Bloomberg*[1], Kevin Watteyne[2], Greg Hudec[3], Charlie Hicks[4]; [1]Bayer CropScience, RTP, NC, [2]Bayer CropScience, Lincoln, NE, [3]Bayer CropScience, Manhattan, KS, [4]Bayer CropScience, Fort Collins, CO (212)

**Possible Use of Indazaflam for Fallow Weed Control One Year Prior to Planting Wheat or Canola.** Jennifer Jester*[1], Randall S. Currie[2]; [1]Kansas State Univ., Garden city, KS, [2]Kansas State University, Garden City, KS (213)

**†Effect of Herbicide Carryover in Cover Crop Capacity to Affect Soil Structure and Nutrient Availability.** Maria R. Rojas*, Darren Robinson, Laura Van Eerd, Ivan O'Halloran; University of Guelph-Ridgetown, Ridgetown, ON (48)

*Presenter; † Student Contestant

**†Effect of Imazethapyr, Mesotrione and Saflufenacil Residues on Four Spring-Seeded Cover Crops.** Li Yu*, Darren Robinson, Peter H. Sikkema; University of Guelph-Ridgetown, Ridgetown, ON (126

## *Equipment and Application Methods*

**†The Effect of Adjuvants and Nozzles on Cloransulam, Glyphosate, and Dicamba Efficacy and Droplet Size.** Fernanda S. Antonio*, Ryan S. Henry, Andre O. Rodrigues, Jesaelen G. Moraes, Rafael Werle, Cody F. Creech, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (27)

**†The Impact of Droplet Size on the Efficacy of 2,4-D, Atrazine, Chlorimuron, Dicamba, Glufosinate, and Saflufenacil.** Jesaelen G. Moraes*, Rafael Werle, Fernanda S. Antonio, Andre O. Rodrigues, Cody F. Creech, Ryan S. Henry, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (28)

**†Glyphosate, Fluazifop, Lactofen, and Dicamba Efficacy as Impacted by Adjuvants and Nozzles.** Andre O. Rodrigues*, Fernanda S. Antonio, Jesaelen G. Moraes, Rafael Werle, Cody F. Creech, Ryan S. Henry, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (29)

**†Herbicide Efficacy as Influenced by Carrier Volume and Weed Size.** Cody F. Creech*[1], Rafael Werle[1], Jesaelen G. Moraes[1], Andre O. Rodrigues[1], Fernanda S. Antonio[1], Ryan S. Henry[1], Lowell Sandell[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (30)

**Efficacy of Dicamba & Glyphosate Applied Through Commercial Application Equipment.** Stephen A. Valenti*[1], Joseph J. Sandbrink[2], Jeff N. Travers[2]; [1]Monsanto, Fargo, ND, [2]Monsanto Company, St. Louis, MO (31)

**Proposed Label Application Requirements for Dicamba in Roundup Ready® Xtend Crop Systems.** Susan E. Curvey*, Jeff N. Travers, Joseph J. Sandbrink, Thomas B. Orr, Helen E. Mero; Monsanto Company, St. Louis, MO (32)

**†Effect of Carrier Volume on Growth Regulator and Contact Herbicide Tank-Mixtures.** Strahinja Stepanovic*[1], Matheus Palhano[1], Greg R. Kruger[2], Lowell Sandell[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (33)

**†Effect of Water Temperature and Storage Duration on MON 76757.** Pratap Devkota*, William G. Johnson; Purdue University, West Lafayette, IN (34)

**†An Evaluation of Three Drift Reduction Technologies for Aerial Application of Pesticides.** Ryan S. Henry*[1], Annah Geyer[1], William E. Bagley[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Wilbur-Ellis, San Antonio, TX (35)

**Drift Reduction to Soybean Fields When Using Best Management Practices with Enlist Duo.** David M. Simpson*, Fikru Haile, Jerome J. Schleier; Dow AgroSciences, Indianapolis, IN (36)

**†The Influence Of Carrier Volume And Spray Nozzle Type On Herbicide Coverage At Late Post Application to 31-cm Tall Soybean.** Travis Legleiter*, William G. Johnson; Purdue University, West Lafayette, IN (136)

**†Interaction of Carrier Water pH and Hardness on the Efficacy of MON 76757 and 2,4-D Choline.** Pratap Devkota*, William G. Johnson; Purdue University, West Lafayette, IN (137)

**Increasing Activity of Growth Regulator Herbicides with Water Conditioners.** Donald Penner*, Jan Michael; Michigan State University, East Lansing, MI (138)

**†Glyphosate, Fluazifop, Lactofen, and Dicamba Efficacy and Droplet Size as Influenced by Adjuvants.** Cody F. Creech*[1], William E. Bagley[2], Lowell Sandell[3], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Wilbur-Ellis, San Antonio, TX, [3]University of Nebraska-Lincoln, Lincoln, NE (139)

**†Tomato Injury and Downwind Deposition from Aerial Applications of Glyphosate.** Ryan S. Henry*[1], Brad Fritz[2], Clint Hoffmann[2], William E. Bagley[3], Andrew Hewitt[1], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]USDA-ARS, College Station, TX, [3]Wilbur-Ellis, San Antonio, TX (140)

**Glyphosate Drift Deposition and Tomato Injury from Ground Applications.** Greg R. Kruger*[1], Ryan S. Henry[1], Cody F. Creech[1], Brad Fritz[2], Clint Hoffmann[2], William E. Bagley[3], Andrew Hewitt[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]USDA-ARS, College Station, TX, [3]Wilbur-Ellis, San Antonio, TX (141)

**Low Volume Dormant Stem Treatments for Extending the Brush Control Season.** Pat Burch[1], Travis Roger[2], Ernest S. Flynn*[3]; [1]Dow AgroSciences, Christiansburg, VA, [2]Dow AgroSciences, Charleston, SC, [3]Dow AgroSciences, Ankeny, IA (166)

**Calibration Technology.** Robert E. Wolf*; Wolf Consulting & Research LLC, Mahomet, IL (167)

**The Effects of Nozzles and Drift Reduction Agents on Droplet Size Distributions of Dicamba and Glyphosate Mixtures.** Thomas B. Orr*[1], Kirk B. Remund[1], Jeff N. Travers[1], Joy L. Honegger[1], Andrew Hewitt[2]; [1]Monsanto Company, St. Louis, MO, [2]University of Nebraska-Lincoln, North Platte, NE (168)

**Evaluating Drift Reduction Technologies for the Control of Glyphosate-resistant Waterhemp Using Dicamba and Glyphosate.** Robert E. Wolf*[1], Scott M. Bretthauer[2], Matthew Gill[2], Bryan G. Young[3], Greg R. Kruger[4]; [1]Wolf Consulting & Research LLC, Mahomet, IL, [2]University of Illinois, Urbana-Champaign, IL, [3]Southern Illinois University, Carbondale, IL, [4]University of Nebraska-Lincoln, North Platte, NE (169)

**Nonionic Surfactant Adjuvant with Optimized Physical and Biological Properties for Herbicide Tank Mixtures.** Gregory J. Lindner*[1], Kevin Penfield[1], Bryan G. Young[2], Marcia Werner[3]; [1]Croda Inc, New Castle, DE, [2]Southern Illinois University, Carbondale, IL, [3]Croda Brasil, Campinas, Brazil (170)

**Atomization of Agricultural Tank Mixtures in Response to a Pulse Width Modulation (PWM) Spray Delivery System.** Lillian C. Magidow*[1], Stephanie Wedryk[1], Donald Penner[2]; [1]Winfield Solutions, St. Paul, MN, [2]Michigan State University, East Lansing, MI (171)

**Minimizing Dicamba Drift with Improved Hooded Sprayers.** Joseph J. Sandbrink*[1], Jeff N. Travers[1], Steve Claussen[2]; [1]Monsanto Company, St. Louis, MO, [2]Willmar, Willmar, MN (172)

**Methods for Deactivating Dicamba Solutions in Agricultural Spray Equipment.** Susan E. Curvey*[1], David A. Morgenstern[1], Jeff N. Travers[1], Joseph J. Sandbrink[1], Ryan J. Rector[2]; [1]Monsanto Company, St. Louis, MO, [2]Monsanto Company, St Louis, MO (173)

**Simple and Reliable Tank Cleaning.** David A. Morgenstern*, Ronald J. Brinker, James W. Taylor, James P. Fornango, Jeff N. Travers; Monsanto Company, St. Louis, MO (174)

## *Extension*

**Use of Non-Traditional Extension Outreach Tools for Turfgrass Weed Science.** Jared A. Hoyle*; Kansas State University, Manhattan, KS (37)

**Manual for Propane-Fueled Flame Weeding in Corn, Soybean, and Sunflower.** Stevan Z. Knezevic*[1], Avishek Datta[2], Chris Bruening[3], George Gogos[3], Jon E. Scott[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska-Lincoln, Lincoln, NE (38)

*Presenter; † Student Contestant

**Time of Weed Removal in Corn and Soybeans, A Field Teaching Tool - Seeing is Believing.** Lisa M. Behnken*[1], Fritz Breitenbach[1], Jeffrey L. Gunsolus[2], Ryan P. Miller[1]; [1]University of Minnesota, Rochester, MN, [2]University of Minnesota, Saint Paul, MN (39)

**Planning and Conducting Field Demonstration Tours.** Bruce E. Maddy*[1], David E. Hillger[2], Gary A. Finn[2], Jeff M.

Ellis[3], Eric F. Scherder[4], David C. Ruen[5], Corey K. Gerber[6], Fritz Koppatschek[7], Luke A. Peters[2]; [1]Dow AgroSciences, Noblesville, IN, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Smithville, MO, [4]Dow AgroSciences, Huxley, IA, [5]Dow AgroSciences, Lanesboro, MN, [6]Purdue University, West Lafayette, IN, [7]ABG Ag Services, Sheridan, IN (40)

**Global Technology Transfer at Dow AgroSciences: Blended Learning for Employee and Customer Education.** Gary A. Finn[1], Bruce E. Maddy[2], Ed King[1], David E. Hillger*[1]; [1]Dow AgroSciences, Indianapolis, IN, [2]Dow AgroSciences, Noblesville, IN (41)

**Take Action: A Cooperative Herbicide Resistance Educational Program.** William G. Johnson, Travis Legleiter*; Purdue University, West Lafayette, IN (42)

**Pro-Active Late-Season Weed Escape Survey Identified Glyphosate-Resistant Horseweed Present at Low Frequency in Wisconsin.** Ross A. Recker*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (43)

**Efficacy of Weed Management Systems in MGI Soybeans.** Bryan G. Young*[1], Lawrence E. Steckel[2], Scott E. Cully[3], James C. Holloway[4]; [1]Southern Illinois University, Carbondale, IL, [2]University of Tennessee, Jackson, TN, [3]Syngenta, Marion, IL, [4]Syngenta, Jackson, TN (182)

**Glyphosate Weeds in Ontario.** Peter H. Sikkema*[1], Darren Robinson[1], Francois Tardif[2], Mark B. Lawton[3], Nader Soltani[1]; [1]University of Guelph-Ridgetown, Ridgetown, ON, [2]University of Guelph, Guelph, ON, [3]Monsanto, Guelph, ON (183)

**A Weed Scientists Perspective on Cover Crops in Missouri.** Kevin W. Bradley*, John Schultz, Eric B. Riley, Jimmy D. Wait; University of Missouri, Columbia, MO (184)

**Italian Ryegrass (*Lolium multiflorum*) - Friend or Foe?** James R. Martin*; University of Kentucky, Princeton, KY (185)

**Enlist Ahead: Novel Management and Stewardship Resources for the Enlist Weed Control System.** David E. Hillger*[1], Jonathan Siebert[2], Ralph Lassiter[3], Byron Hendrix[4], John Laffey[5], Gary A. Finn[1], Bruce E. Maddy[6], Eric Thorson[1], Damon Palmer[1]; [1]Dow AgroSciences, Indianapolis, IN, [2]Dow AgroSciences, Leland, MS, [3]Dow AgroSciences, Cary, NC, [4]Dow AgroSciences, Lakeville, MN, [5]Dow AgroSciences, Maryville, MO, [6]Dow AgroSciences, Noblesville, IN (186)

**Roundup Ready Learning Xperience - A New Training Tool.** Sara M. Allen*[1], Michelle M. Vigna[2], Simone Seifert-Higgins[2], Joseph J. Sandbrink[2], Adam M. Marschel[2], Barry L. Rogers[2], Matthew J. Helms[2], Tony D. White[2]; [1]Monsanto, Bonnie, IL, [2]Monsanto Company, St. Louis, MO (187)

**Stewardship for BASF Herbicides.** Luke L. Bozeman*[1], Sandra Wilson[1], Robert E. Wolf[2], Daniel Pepitone[1]; [1]BASF Corporation, Research Triangle Park, NC, [2]Wolf Consulting & Research LLC, Mahomet, IL (188)

## *Horticulture, Ornamentals, Turf, and Industrial*

**Comparison of Newer and Older Herbicide Options for Guardrails.** Joe Omielan*, William Witt; University of Kentucky, Lexington, KY (46)

**†Herbicide Combinations for the Control of Nimblewill in Kentucky Bluegrass Lawns.** Michael Barrett, Alexandra P. Williams*; University of Kentucky, Lexington, KY (47)

**Does Cyprosulfamide Safen Isoxaflutole in Sweet Corn?** Darren Robinson*, Nader Soltani, Christy Shropshire, Peter H. Sikkema; University of Guelph-Ridgetown, Ridgetown, ON (49)

**Weed Management Options During Wine Grape Establishment.** Collin Auwarter*, Harlene M. Hatterman-Valenti, John E. Stenger; North Dakota State University, Fargo, ND (50)

**†Dose Responses of Silvery-Thread Moss to Applications of Carfentrazone-ethyl.** Zane M. Raudenbush*, Steven J. Keeley, Mithila Jugulam; Kansas State University, Manhattan, KS (142)

**'Cody' Buffalograss Tolerance to Combination Postemergent Herbicides.** Jared A. Hoyle*; Kansas State University, Manhattan, KS (143)

**†Investigating *Poa annua* Biotypes Collected from Golf Greens: Greenhouse Evaluations.** Alexandra P. Williams*, Michael Barrett, David W. Williams; University of Kentucky, Lexington, KY (144)

**Tolerance of Red Raspberry to Clopyralid Applied Pre-harvest, Post-harvest, Early- and Late-fall.** Constanza Echaiz, Doug Doohan*; The Ohio State University, Wooster, OH (145)

**Evaluation of Season-Long Weed Management Options in Potato.** Jed Colquhoun*, Daniel Heider, Richard Rittmeyer; University of Wisconsin, Madison, WI (146)

**Effect of Simulated Glyphosate Drift to Russet Potato Cultivars Grown for Seed Production.** Harlene M. Hatterman-Valenti*, Collin Auwarter; North Dakota State University, Fargo, ND (147)

**A Comparison of Synergistic Effects of Glyphosate and Bromoxynil Drift with In-Crop Herbicides in Tomato.** Darren Robinson*, Kristen E. McNaughton, Peter H. Sikkema; University of Guelph-Ridgetown, Ridgetown, ON (148)

## *Herbicide Physiology*

**†Characterization of an Indiana Palmer Amaranth Population Resistant to Glyphosate.** Doug J. Spaunhorst*, William G. Johnson; Purdue University, West Lafayette, IN (51)

**Inheritance of Atrazine Resistance in Palmer Amaranth.** Mithila Jugulam*, Amar S. Godar, Curtis R. Thompson; Kansas State University, Manhattan, KS (52)

**†Biochemical Basis for Metabolism-based Atrazine Resistance in waterhemp.** Anton F. Evans*, Rong Ma, Jacqueline Janney, Brittany A. Janney, Dean E. Riechers; University of Illinois, Urbana-Champaign, IL (53)

**†Influence of Soil Residual Fomesafen and Dicamba Tank-Mixtures on the Frequency of PPO-Resistant Waterhemp.** Theresa A. Reinhardt*, R. Joseph Wuerffel, Julie M. Young, Bryan G. Young; Southern Illinois University, Carbondale, IL (54)

**†EPSPS Pro106Ser Substitution in a Glyphosate Resistant Goosegrass Population from Tennessee.** Janel L. Huffman*[1], Chance W. Riggins[1], Lawrence E. Steckel[2], Patrick Tranel[1]; [1]University of Illinois, Urbana-Champaign, IL, [2]University of Tennessee, Jackson, TN (55)

**Differential Response of Lambsquarters from Kansas to Glyphosate.** Randall DeGreeff*, Amar S. Godar, Anita Dille, Dallas E. Peterson, J. Mithila; Kansas State University, Manhattan, KS (56)

*Presenter; † Student Contestant

**†Inheritance of Glyphosate Resistance in Kochia.** Kindsey Niehues*, J. Mithila; Kansas State University, Manhattan, KS (57)

**Multiple Hebicide-Resistant Kochia from Kansas.** J. Mithila*[1], Amar S. Godar[1], Randall S. Currie[2], Anita Dille[1], Curtis R. Thompson[1], Phillip W. Stahlman[3]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Garden City, KS, [3]Kansas State University, Hays, KS (58)

**†Transfer of Phenoxy Resistance from Wild Radish to Canola via Embryo Rescue.** Andrew Dillon*, Mithila Jugulam; Kansas State University, Manhattan, KS (59)

**†A Multi-State Study of the Association Between Glyphosate Resistance and EPSPS Gene Amplification in Waterhemp.** Laura A. Chatham*[1], Chance W. Riggins[1], James R. Martin[2], Greg R. Kruger[3], Kevin W. Bradley[4], Dallas E. Peterson[5], Mithila Jugulam[5], Patrick Tranel[1]; [1]University of Illinois, Urbana-Champaign, IL, [2]University of Kentucky, Princeton, KY, [3]University of Nebraska-Lincoln, North Platte, NE, [4]University of Missouri, Columbia, MO, [5]Kansas State University, Manhattan, KS (127)

**Non-Target-Site Resistance to ALS Inhibitors in Waterhemp.** Jiaqi Guo*, Chance W. Riggins, Nicholas Hausman, Aaron G. Hager, Dean E. Riechers, Patrick Tranel; University of Illinois, Urbana-Champaign, IL (128)

**†Absorption and Translocation of 2,4-D in Resistant and Susceptible *Amaranthus tuberculatus*.** Lacy J. Valentine*[1], J. Mithila[2], Amar S. Godar[2], Zac Reicher[1], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Kansas State University, Manhattan, KS, [3]University of Nebraska-Lincoln, North Platte, NE (129)

**Mesotrione Resistance is Increased Under Elevated Growth Temperatures in Palmer Amaranth.** Amar S. Godar, Mithila Jugulam*, P. V. Vara Prasad; Kansas State University, Manhattan, KS (130)

**†*Amaranthus* Species: Pollen Expression of EPSP Synthase and *In Vitro* Pollen Germination.** Tye C. Shauck*, Reid J. Smeda; University of Missouri, Columbia, MO (131)

**†New Evidence for Multiple Glyphosate-Resistance Mechanisms Within a Population of Common Ragweed.** Jason T. Parrish*[1], Mark M. Loux[1], David M. Mackey[1], Leah K. McHale[1], Doug Sammons[2], Dafu Wang[2], Elizabeth L. Ostrander[3], Dana A. d'Avignon[3], Xia Ge[3], Philip Westra[4], Christopher R. Van Horn[4], Andrew T. Wiersma[5]; [1]The Ohio State University, Columbus, OH, [2]Monsanto Company, St. Louis, MO, [3]Washington University, St. Louis, MO, [4]Colorado State University, Fort Collins, CO, [5]Michigan State University, East Lansing, MI (132)

**†Uptake, Translocation, and Metabolism of 2,4-D in Enlist Soybeans.** Joshua J. Skelton*[1], David M. Simpson[2], Dean E. Riechers[1]; [1]University of Illinois, Urbana-Champaign, IL, [2]Dow AgroSciences, Indianapolis, IN (133)

**Kochia Populations Response to Glyphosate and EPSPS Gene Copy Number.** Amar S. Godar*[1], Phillip W. Stahlman[2], Mithila Jugulam[1], Anita Dille[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS (134)

**Evolution and Status of Glyphosate Resistant Kochia in American Great Plains.** Philip Westra*[1], Andrew T. Wiersma[2]; [1]Colorado State University, Fort Collins, CO, [2]Michigan State University, East Lansing, MI (135)

## *Weed Biology, Ecology, Management*

**†Effect of Cover Crop and Winter Annual Weed Removal Timing and Soybean Planting Date on Soybean Yield.** Deanne Corzatt*, Mark L. Bernards; Western Illinois University, Macomb, IL (60)

**Glyphosate-Resistant Waterhemp Response to Glyphosate Doses in Nebraska.** Jordan Moody*[1], Lucas Baldridge[1], Lowell Sandell[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (61)

**†Measuring Ecological Fitness in the Absence of Herbicide Selection of Five Herbicide-Resistance Traits in Waterhemp using a Multi-Generation Greenhouse Study.** Chenxi Wu*[1], Adam S. Davis[2], Patrick Tranel[1]; [1]University of Illinois, Urbana-Champaign, IL, [2]USDA-Agricultural Research Service, Urbana, IL (62)

**Use of Residual Herbicides to Control Waterhemp and Palmer Amaranth.** Lucas Baldridge*[1], Jordan Moody[1], Strahinja Stepanovic[1], Lowell Sandell[1], Lawrence E. Steckel[2], Jason K. Norsworthy[3], Bryan G. Young[4], Kevin W. Bradley[5], William G. Johnson[6], Mark M. Loux[7], Vince M. Davis[8], Thomas W. Eubank[9], Greg R. Kruger[10]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Tennessee, Jackson, TN, [3]University of Arkansas, Fayetteville, AR,

[4]Southern Illinois University, Carbondale, IL, [5]University of Missouri, Columbia, MO, [6]Purdue University, West Lafayette, IN, [7]The Ohio State University, Columbus, OH, [8]University of Wisconsin-Madison, Madison, WI, [9]Mississippi State University, Stoneville, MS, [10]University of Nebraska-Lincoln, North Platte, NE (63)

**Waterhemp Resistance to Post Emergent Application of HPPD Herbicides.** Stevan Z. Knezevic*[1], Jon E. Scott[1], Aaron S. Franssen[2], Vinod K. Shivrain[3]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Syngenta Crop Protection, Seward, NE, [3]Syngenta Crop Protection, Vero Beach, FL (64)

**†Differential Responses to Atrazine Preemergence and Postemergence in Two Populations of Atrazine-resistant Waterhemp from Illinois.** Rong Ma*[1], Anton F. Evans[1], Shiv S. Kaundun[2], Brittany A. Janney[1], Dean E. Riechers[1]; [1]University of Illinois, Urbana-Champaign, IL, [2]Syngenta UK, Berkshire, England (65)

**†Landscape Movement of 2,4-D Resistance in waterhemp.** Lacy J. Valentine*[1], Zac Reicher[1], Patrick Tranel[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Illinois, Urbana-Champaign, IL, [3]University of Nebraska-Lincoln, North Platte, NE (66)

**†Growth Rate, Dry Matter Accumulation, and Seed Yield of Common Waterhemp.** Joseph M. Heneghan*, William G. Johnson; Purdue University, West Lafayette, IN (67)

**†Impact of Emergence Date on Reproductive Potential of Amaranthus.** Heidi R. Davis*, Reid J. Smeda; University of Missouri, Columbia, MO (68)

**Emergence Patterns of Waterhemp in Nebraska in 2013.** Chandra J. Hawley*[1], Lacy J. Valentine[2], Lowell Sandell[2], Amit J. Jhala[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (69)

**†Waterhemp Control Under Varying Drought Stress Conditions with 2,4-D and Glyphosate.** Joshua J. Skelton*, Brittany A. Janney, Dean E. Riechers; University of Illinois, Urbana-Champaign, IL (70)

**†Identifying Gender-specific DNA Markers in Waterhemp.** Ahmed Sadeque*, Patrick J. Brown, Patrick Tranel; University of Illinois, Urbana-Champaign, IL (71)

**†Characterization of Illinois Populations of Waterhemp and Palmer Amaranth for Herbicide Mode-of-Action Sensitivity and Soil Residual Activity.** Jamie L. Long*, Julie M. Young, Bryan G. Young; Southern Illinois University, Carbondale, IL (72)

**†Emergence Patterns of Waterhemp and Palmer amaranth in the Southern and Midwestern U.S.** Lucas X. Franca*[1], Bryan G. Young[1], Jason K. Norsworthy[2], Thomas W. Eubank[3], Lawrence E. Steckel[4], Mark M. Loux[5], William G. Johnson[6], Vince M. Davis[7], Reid J. Smeda[8], Greg R. Kruger[9]; [1]Southern Illinois University, Carbondale, IL, [2]University of Arkansas, Fayetteville, AR, [3]Mississippi State University, Stoneville, MS, [4]University of Tennessee, Jackson, TN, [5]The Ohio State University, Columbus, OH, [6]Purdue University, West Lafayette, IN, [7]University of Wisconsin-Madison, Madison, WI, [8]University of Missouri, Columbia, MO, [9]University of Nebraska-Lincoln, North Platte, NE (73)

*Presenter; † Student Contestant

**Historical Distribution of Giant Ragweed and Cocklebur in the North Central Region.** Ramarao Venkatesh*[1], Robert A. Ford[1], Emilie E. Regnier[1], Steven K. Harrison[1], Christopher Holloman[1], Robin Taylor[2], Florian Diekmann[1]; [1]The Ohio State University, Columbus, OH, [2]Texas A&M University, Temple, TX (74)

**GIS Analysis of Glyphosate Resistance in Giant Ragweed .** Robert A. Ford*[1], Ramarao Venkatesh[1], Emilie E. Regnier[1], Steven K. Harrison[1], Christopher Holloman[1], Robin Taylor[2], Florian Diekmann[1]; [1]The Ohio State University, Columbus, OH, [2]Texas A&M University, Temple, TX (75)

**Metagenomic Evaluation of Rhizosphere Microbial Community Dynamics in Glyphosate-Treated Giant Ragweed**

**Biotypes.** Jessica R. Schafer*, Steve G. Hallett, William G. Johnson; Purdue University, West Lafayette, IN (76)

**Giant Ragweed Resistance to Glyphosate in Nebraska.** Stevan Z. Knezevic*[1], Jon E. Scott[1], Avishek Datta[2]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Asian Institute of Technology, Bangkok, Thailand (77)

**†Emergence Time of Summer and Winter Annual Weeds in the Midwestern USA.** Rodrigo Werle*[1], Lowell Sandell[1], Mark L. Bernards[2], Doug Buhler[3], Bob G. Hartzler[4], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Western Illinois University, Macomb, IL, [3]Michigan State University, East Lansing, MI, [4]Iowa State University, Ames, IA (78)

**†Defining the Weed Host Range of *Clavibacter michiganensis* subsp. *nebraskensis*, Causal Agent of Goss's Wilt of Corn.** Joseph Ikley*, Kiersten Wise, William G. Johnson; Purdue University, West Lafayette, IN (79)

**†Influence of Cereal Rye and Annual Ryegrass Cover Crops on Management of Glyphosate Resistant Horseweed.** Tyler A. Johnson*, Mark M. Loux; The Ohio State University, Columbus, OH (80)

**†Impact of Weed Management and Nitrogen Rate on Nitrous Oxide Emissions in Corn.** Rebecca R. Bailey*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (81)

**†Herbicide Carryover Evaluation in Cover Crops Following Corn and Soybean Herbicides.** Daniel H. Smith*[1], Travis Legleiter[2], Elizabeth J. Bosak[1], William G. Johnson[2], Vince M. Davis[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Purdue University, West Lafayette, IN (82)

**†Winter Annual Weed Suppression with Oilseed Radish.** Sandler Leah*, Kelly Nelson; University of Missouri, Columbia, MO (83)

**Impact of Cover Crops on Weed Dynamics in Organic Dry Beans.** Erin C. Hill*, Karen A. Renner, Christy L. Sprague; Michigan State University, East Lansing, MI (84)

**†Fitness of Sorghum, Shattercane and Their F2 Hybrid Progeny.** Jared J. Schmidt*[1], Scott Sattler[2], Diana Pilson[1], Aaron J. Lorenz[1], Jeff f. Pedersen[2], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]USDA-ARS, Lincoln, NE (85)

**Weed Control in Shelterbelts.** Devin A. Wirth*, Richard K. Zollinger; North Dakota State University, Fargo, ND (86)

**†Kochia Seed Characteristics Under Different Crop Canopies.** Andrew Esser*, Anita Dille; Kansas State University, Manhattan, KS (113)

**†Influence of Emergence Timing on the Vegetative and Reproductive Development of Palmer Amaranth in Indiana.** Doug J. Spaunhorst*, William G. Johnson; Purdue University, West Lafayette, IN (114)

**†Influence of Spring Tillage on Emergence of Giant Ragweed in Nebraska.** Rodrigo Werle*, Lowell Sandell, Simranpreet Kaur, Amit J. Jhala, John L. Lindquist; University of Nebraska-Lincoln, Lincoln, NE (115)

*Presenter; † Student Contestant

**†Giant Ragweed Seed Production and Retention in Soybean and Field Margins.** Jared J. Goplen*[1], Jeffrey L. Gunsolus[1], Craig Sheaffer[1], Roger Becker[1], Jeffrey Coulter[1], Fritz Breitenbach[2], Lisa M. Behnken[2], Gregg Johnson[3]; [1]University of Minnesota, Saint Paul, MN, [2]University of Minnesota, Rochester, MN, [3]University of Minnesota SROC, Waseca, MN (116)

**†Control of Glyphosate Resistant Horseweed with Glyphosate DMA/2,4-D Choline (Enlist Duo) in Corn.** Laura R. Ford*[1], Darren Robinson[1], Allan McFadden[2], Nader Soltani[1], Robert Nurse[3], Peter H. Sikkema[1]; [1]University of Guelph-Ridgetown, Ridgetown, ON, [2]Dow AgroSciences Canada Inc, Guelph, ON, [3]Agriculture and Agri-Food Canada, Harrow, ON (117)

**†Impact of Herbicides on *Clavibacter michiganensis* subsp. *nebraskensis*, Causal Agent of Goss's Wilt of Corn.** Joseph Ikley*, Kiersten Wise, William G. Johnson; Purdue University, West Lafayette, IN (118)

**†Effect of Humidity and Humectant on Glufosinate Efficacy.** Andrew R. Kniss[1], Carl W. Coburn*[1], Richard K. Zollinger[2]; [1]University of Wyoming, Laramie, WY, [2]North Dakota State University, Fargo, ND (119)

**†Response of Common Waterhemp to Waterstress.** Debalin Sarangi*, John L. Lindquist, Suat Irmak, Amit J. Jhala; University of Nebraska-Lincoln, Lincoln, NE (120)

**†Status of Herbicide Resistance in Ohio Amaranthus spp.** Samantha N. Konkle*, Mark M. Loux, Tony Dobbels; The Ohio State University, Columbus, OH (121)

**†Nitrous Oxide Emissions as Influenced by Nitrogen and Weeds Before and After Postemergence Glyphosate Application.** Rebecca R. Bailey*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (122)

**†Concomitant Nutrient Release of Decaying Weed Residues Following Postemergent Weed Control.** Nick T. Harre*, Bryan G. Young, Jon E. Schoonover; Southern Illinois University, Carbondale, IL (123)

**†The Applicability of Tilman's Resource Ratio Theory to Four Amaranthaceae Species.** Lauren M. Schwartz*, Bryan G. Young, David J. Gibson; Southern Illinois University, Carbondale, IL (124)

**†The Effect of Mob Grazing on Canada thistle Control, Pasture Productivity and Utilization, and Forage Quality.** Anders M. Gurda*[1], Mark J. Renz[1], Geoffrey E. Brink[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]USDA-ARS Dairy Forage Research Center, Madison, WI (125)

**Effect of Winter Wheat Cover Crop Residue on Dry Bean Development and Harvest Loss.** Andrew R. Kniss*[1], Robert Baumgartner[2], David Claypool[1]; [1]University of Wyoming, Laramie, WY, [2]University of Wyoming, Lingle, WY (175)

**Benefits and Economics of "The Critical Period of Competition" and "The ZeroSeed Threshold" Weed Management Strategies for Transitioning to Organic Farming.** Mohsen Mohseni-Moghadam*[1], Karen Amisi[2], Doug Doohan[3]; [1]OSU-OARDC, Wooster, OH, [2]Grand Valley State University, Allendale, MI, [3]The Ohio State University, Wooster, OH (176)

**Can Overproduction of EPSPS Enhance Fitness in Certain Glyphosate-Resistant Weeds?: Avenues for Research.** Allison A. Snow*, Mark M. Loux, Bruce A. Ackley, David M. Mackey, Zachery T. Beres; The Ohio State University, Columbus, OH (177)

**Impact of Management and Atrazine Use on Late-Season Weed Escapes in Wisconsin Corn and Soybean Fields.** Ross A. Recker*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (178)

*Presenter; † Student Contestant

**Palmer Amaranth: A Looming Threat to Soybean Production in the North Central Region?** Adam S. Davis*[1], Aaron G. Hager[2], Bryan G. Young[3]; [1]USDA-Agricultural Research Service, Urbana, IL, [2]University of Illinois, Urbana-Champaign, IL, [3]Southern Illinois University, Carbondale, IL (179)

**Something Wicked This Way Comes: New Reports and Herbicide Resistance Profiles of Invasive Palmer Amaranth Populations in Illinois.** Chance W. Riggins*, Aaron G. Hager, Patrick Tranel; University of Illinois, Urbana-Champaign, IL (180)

**Survey of Giant Ragweed Distribution and Spread in the North Central Region.** Emilie E. Regnier*[1], Christopher Holloman[1], Steven K. Harrison[1], Mark M. Loux[1], Ramarao Venkatesh[1], Robert A. Ford[1], Robin Taylor[2], Florian Diekmann[1]; [1]The Ohio State University, Columbus, OH, [2]Texas A&M University, Temple, TX (181)

## *Invasive Plants*

**The Great Lakes Phragmites Collaborative: Building a Communication Stategy to Increase Regional Collaboration on Invasive Species Management.** Amanda Sweetman*[1], Spphie Taddeo[1], Heather Braun[1], Kurt P. Kowalski[2]; [1]Great Lakes Commission, Ann Arbor, MI, [2]USGS-Great Lakes Science Center, Ann Arbor, MI (87)

**Invasive Phragmites in Great Lakes Coastal Corriors: Combining Radar Mapping and Habitat Suitability Modeling in an Online Decision Support Tool.** Wesley A. Bickford*[1], Kurt P. Kowalski[1], Martha L. Carlson Mazur[2], Mike R. Eggleston[1]; [1]USGS-Great Lakes Science Center, Ann Arbor, MI, [2]Boston College, Chestnut Hill, ME (88)

**Invasive Plant and Native Amphibian Interactions.** Lisa Regula Meyer*; Kent State University, Kent, OH (89)

**Is the Solution Worse Than the Problem?  Examining the Effects of *Myriophyllum spicatum* and Triclopyr on *Lithobates pipiens* Tadpoles.** Amanda Curtis*, M. Gabriela Bidart-Bouzat; Bowling Green State University, Bowling Green, OH (90)

**Historic Mining and Agriculture as Indicators of Presence and Distribution of Two Widespread Invasive Plant Species.** Kellen M. Calinger*, Elisabeth Calhoon, Hsiao-chi Chang; Ohio State University, Columbus, OH (91)

**The Effect of Invasive Species on Grassland Bird Nesting.** Chelsea L. Merriman*, Kerri C. Martin; University of Notre Dame, South Bend, IN (92)

**Does the Rare, Native West Virginia White Butterfly (*Pieris virginiensis*) Oviposit on Invasive Garlic Mustard (*Alliaria petiolata*)?** Samantha L. Davis*, Don Cipollini; Wright State University, Fairborn, OH (93)

**Invasive Plant Dynamics in Ash Ecosystems.** Kathleen Knight*; USDA Forest Service, Delaware, OH (94)

**Native-Invasive Tree Litter Mixtures Enhance Invasive Species' Impacts on Nutrient Cycling During the Growing Season.** Michael J. Schuster*, Jeffrey S. Dukes; Purdue University, West Lafayette, IN (95)

**Exploring Direct and Indirect Comparative Allelopathic Effects of Invasive *Lonicera japonica* and Native *Lonicera sempervirens*.** Nate Godby*, Kendra Cipollini; Wilmington College, Wilmington, OH (96)

**Factors Associated with Invasive Plant Distribution along Wisconsin Roadsides.** Mark J. Renz*[1], Joslyn Mink[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin, Madison, Madison, WI (189)

**Effects of Three Common Buckthorn Removal Techniques on the Regeneration of Understory Vegetation.** Alexander M. Roth*, Alexandra G. Lodge, Lee E. Frelich, Peter B. Reich; University of Minnesota, St. Paul, MN (190)

**Foliar-Applied Herbicides for Saltcedar Control.** Walter H. Fick*; Kansas State University, Manhattan, KS (191)

***Ailanthus* Wilt, a Potential Biocontrol Agent in Ohio Forests?** Joanne Rebbeck*[1], Joan Jolliff[1], Donald Davis[2], Eric O'Neal[2]; [1]Northern Research Station, Delaware, OH, [2]Penn State University, University Park, PA (192)

**The Effects of Site Fertility on Biological Control Targeting Purple Loosestrife (*Lythrum salicaria*).** Stephen M. Hovick*[1], Chris J. Peterson[2], Walter P. Carson[3]; [1]The Ohio State University, Columbus, OH, [2]University of Georgia, Athens, GA, [3]University of Pittsburgh, Pittsburgh, PA (193)

**Vegetative Dispersal of an Invasive Bioenergy Crop: Should We Be Worried?** Natalie M. West*[1], David P. Matlaga[2], Adam S. Davis[1]; [1]USDA-Agricultural Research Service, Urbana, IL, [2]Susquehanna University, Selinsgrove, PA (194)

**The Effect of Emerald Ash Borer-Caused Canopy Gaps on Understory Invasive Shrubs and Forest Regeneration.** Brian M. Hoven*[1], David Gorchov[1], Kathleen Knight[2]; [1]Miami University, Oxford, OH, [2]USDA Forest Service, Delaware, OH (195)

**Aminopyralid Research Summary for Aquatic Labeling.** Vanelle F. Peterson[1], John Jachetta[2], Patrick L. Havens[2], Louise A. Brinkworth[2], William Kline[3], William T. Haller[4], John Troth[2], Ernest S. Flynn*[5]; [1]Dow AgroSciences LLC, Mulino, OR, [2]Dow AgroSciences LLC, Indianapolis, IN, [3]Private Researcher, Ballground, GA, [4]University of Georgia, Gainesville, FL, [5]Dow AgroSciences, Ankeny, IA (196)

**Functional Trait Differences between Native and Invasive Plants in Deciduous Forests of the Upper Midwest.** Alexandra G. Lodge*[1], Alexander M. Roth[1], Timothy Whitfeld[2], Peter B. Reich[1]; [1]University of Minnesota, St. Paul, MN, [2]Brown University, Providence, RI (197)

**Effects of the Invasive Shrub *Lonicera maackii* and a Generalist Herbivore, White-tailed Deer, on Forest Floor Plant Community Composition.** Jessica R. Peebles-Spencer*, David Gorchov; Miami University, Oxford, OH (198)

**The Role of White-tailed Deer in Long-distance Dispersal of Amur Honeysuckle (*Lonicera maackii*).** Peter W. Guiden*, David Gorchov; Miami University, Oxford, OH (199)

**The Effect of Treefall Gaps on the Spatial Distribution and Dispersal of Four Invasive Plants in a Mature Secondary Upland Forest in Maryland.** Angela Klinczar*[1], Charlotte Freeman[2], Nicole Angeli[3], David Gorchov[4]; [1]Miami University, Orchard Park, NY, [2]Purdue University, West Lafayette, IN, [3]Texas A&M University, College Station, TX, [4]Miami University, Oxford, OH (200)

**Developing Innovative Management Strategies for the Invasive *Phragmites australis*.** Kurt P. Kowalski, Wesley A. Bickford*; USGS-Great Lakes Science Center, Ann Arbor, MI (201)

**Plant Community Development Following Restoration Treatments on a Legacy Reclaimed Mine Site.** Keith E. Gilland*[1], Caleb J. Cochran[1], Julia I. Chapman[2], Jenise M. Bauman[1]; [1]Miami University, Middletown, OH, [2]University of Dayton, Dayton, OH (202)

**Prairie Reconstruction: A Weed is a Weed is a... Placeholder?** Diane L. Larson*; U.S. Geological Survey - Biological Resources Division at Northern Prairie Wildlife Research Center, Minneapolis, MN (214)

*Presenter; † Student Contestant

**Chemical Explanations for the Impacts of Invasive Plants: How Important Are They?** Don Cipollini*; Wright State University, Fairborn, OH (215)

**What's New in Invasion Biology, and Why is it Controversial?** Daniel Simberloff*; University of Tennessee, Knoxville, TN (216)

**The Midwest Invasive Plant Network's Control Information Database: A Resource for Natural Resource Managers and Landowners.** Katherine M. Howe*[1], Brendon J. Panke[2], Mark J. Renz[2]; [1]Purdue University, Indianapolis, IN, [2]University of Wisconsin-Madison, Madison, WI (217)

**GLEDN: How to Report Invasive Plant Locations and Sign Up for Alerts.** Mark J. Renz*, Brendon J. Panke; University of Wisconsin-Madison, Madison, WI (218)

**Tracking Invasive Species: We Have An App For That!** Kathy Smith*; Ohio State University Extension, Columbus, OH (219)

**IMapInvasives - An Emerging Online Reporting Tool for Early Detection Rapid Response.** Amy Stauffer*; Western PA Conservancy, Pittsburgh, PA (220)

**Communicating Hydrilla Search Efforts in New York: Using iMapInvasives with Professionals and Volunteers.** Jennifer M. Dean*; NY Natural Heritage Program, Albany, NY (221)

**Reaching Consumers: Smart Phone App for Landscape Alternatives for Invasive Plants.** Lara A. Vallely*[1], Katherine M. Howe[1], Mark J. Renz[2], Chuck Bargeron[3]; [1]Purdue University, Indianapolis, IN, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Georgia, Tifton, GA (222)

**Update on Green Industry Outreach Efforts in the Midwest.** Cathy A. McGlynn*; Northeast Illinois Invasive Plant Partnership, Glencoe, IL (223)

**Go Beyond Beauty: Community-Based Solutions for Working with Nurseries to Remove Invasive Ornamental Plants from Trade.** Mathew Bertrand*; Michigan State University, Suttons Bay, MI (224)

**Cultivating Awareness: Using Video to Demonstrate the Impacts of Invasive Ornamental Plants in Natural Areas.** Katherine M. Howe*[1], Mark J. Renz[2], Brendon J. Panke[2], Cathy A. McGlynn[3]; [1]Purdue University, Indianapolis, IN, [2]University of Wisconsin-Madison, Madison, WI, [3]Northeast Illinois Invasive Plant Partnership, Glencoe, IL (225)

**Successful Phragmites Control in Northeast Ohio Watersheds.** Karen Adair*; The Nature Conservancy, Rock Creek, OH (226)

**Management of Invasive Woody Vines.** Chris W. Evans*; Illinois Wildlife Action Plan, Marion, IL (227)

**Biology and Control of Ailanthus.** Eric Boyda*; Appalachian Ohio Weed Control Partnership, Pedro, OH (228)

**Assessing and Predicting the Risk of Non-Native Plant Invasions in Florida's Natural Areas.** Deah Lieurance*[1], S L. Flory[2]; [1]UF/IFAS Assessment, Gainesville, FL, [2]University of Florida, Gainesville, FL (229)

**Assessing Invasive Plants in Ohio: The Process and Progress of the Ohio Invasive Plants Council Assessment Program.** Theresa M. Culley*; University of Cincinnati, Cincinnati, OH (230)

**Assessment of Invasive Species in Indiana's Natural Areas.** Ellen Jacquart[1], Katherine M. Howe*[2]; [1]The Nature Conservancy, Indianapolis, IN, [2]Purdue University, Indianapolis, IN (231)

**Standardizing the Creation of Invasive Plant Lists.** Susan Gitlin*; US Environmental Protection Agency, Washington, DC (232)

**Invasion Dynamics of Amur Honeysuckle in Southwest Ohio.** David Gorchov*, Mary Henry; Miami University, Oxford, OH (233)

**Species Influences on Ecosystems Processes: Context-Dependent Impacts of the Invasive *Lonicera maackii*.** Sarah Bray[1], Megan Poulette[2], Mary A. Arthur*[3]; [1]Transylvania University, Lexington, KY, [2]Cornell College, Mt. Vernon, IA, [3]University of Kentucky, Lexington, KY (234)

**Amur Honeysuckle Interactions with Pollinators: Consequences for Reproduction of Both Invader and Native Plants.** Karen Goodell*; Ohio State University, Newark, OH (235)

**Management of Amur Honeysuckle in Hamilton County Ohio Parks: A Case Study.** Tom Borgman*; Great Parks of Hamilton County, Cincinnati, OH (236)

**Plant-Herbivore Interactions and the Invasion of Amur Honeysuckle in North America.** Deah Lieurance*; UF/IFAS Assessment, Gainesville, FL (237)

**"The Plan to Win" Amur Honeysuckle Removal and Restoration in the Five Rivers MetroParks.** Mary Klunk*; Five Rivers MetroParks, Dayton, OH (238)

**Riparian Zone Invasion of Amur Honeysuckle Alters Headwater Stream Biota and Ecosystem Function.** Rachel E. McNeish*, Mark E. Benbow, Ryan W. McEwan; University of Dayton, Dayton, OH (239)

**Comprehensive System for Controlling Amur Honeysuckle.** Donald Geiger*; Univ. of Dayton, Dayton, OH (240)

**Inferring Invasion Patterns of *Lonicera maackii* in Southwestern Ohio from the Genetic Structure of Established Populations.** Oscar J. Rocha*; Kent State University, Kent, OH (241)

**Recovery of Forest Communities after Amur Honeysuckle Removal.** Richard L. Boyce*; Northern Kentucky University, Highland Heights, KY (242)

**A Price to Pay for Restoration? Soil Loss Associated with Amur Honeysuckle Removal in Olmsted Parks of Louisville, KY.** Margaret M. Carreiro*[1], Major Waltman[2]; [1]University of Louisville, Louisville, KY, [2]Louisville Olmsted Parks Conservancy, Louisville, KY (243)

## *Symposium: Technology Tools and Communication Trends for Weed Scientists*

**Symposium Introduction.** Vince M. Davis*; University of Wisconsin-Madison, Madison, WI (149)

**Getting Growers to Go Digital: The Power of a Positive User Experience.** Brian McCornack*; Kansas State University, Manhattan, KS (150)

**You Tube, Social Media, Google Tools, etc...Extension Today@#MSUweedscience.** Erin C. Hill*; Michigan State University, East Lansing, MI (151)

**The Nebraska Weed Guide: An Interactive Experience.** Lowell Sandell*[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (152)

*Presenter; † Student Contestant

**Development of the NDSU Pest Management App.** Angela J. Kazmierczak*; North Dakota State University, Fargo, ND (153)

**#Etiquette: Social Media BMP's.** Dawn Refsell*; Valent USA, Columbia, MO (154)

**Increase the Impact of Your Programs through Branding and Communications.** Karen Pfautsch*; OsbornBarr, St. Louis, MO (155)

*Presenter; † Student Contestant

# Abstracts

COMMON WINDGRASS MANAGEMENT IN WINTER WHEAT. Christy L. Sprague*; Michigan State University, East Lansing, MI (1)

Common windgrass (*Aperia spica-venti* L.) is a winter annual grass species that has become more of a weed problem in winter wheat production in Michigan. Difficulty in management of this weed has been due to its emergence pattern that closely coincides with winter wheat, growth that is similar to winter wheat, and the limited availability of selective herbicides. A field trial was conducted over two winter wheat growing seasons (2011-2012 and 2012-2013) in Minden City, MI to investigate possible windgrass management strategies. Mesosulfuron (15 g $ha^{-1}$) and pyroxsulam (18 g $ha^{-1}$), each applied with a non-ionic surfactant (0.25% v/v) + ammonium sulfate (2.2 kg $ha^{-1}$) were applied in the fall when common windgrass was 0.6 to 1.27 cm tall and wheat was at Feeke's stage 2 and in the spring when common windgrass was 8 cm tall and wheat was at Feeke's stage 4. Additional treatments applied in the spring were pinoxaden (60 g ha$^{-1}$) and fenoxaprop (93 g ha$^{-1}$). Fall-applied mesosulfuron and pyroxsulam provided excellent control (>95%) of common windgrass in the spring. At the end of the growing season mesosulfuron and pyroxsulam resulted in 89% and 98% control, respectively, from the fall applications. Applications in the spring from these herbicides also resulted in excellent control (>95%) at the end of the season. However, the speed of activity of these herbicides from spring applications was extremely slow. Common windgrass control averaged only around 70%, 21 DAT, for these herbicides. Windgrass control from pinoxaden and fenoxaprop was also slow from spring applications and was not as complete as spring applications of mesosulfuron or pyroxsulam at the end of the season. Control at the end of the season was 65% and 83% from fenoxaprop and pinoxaden, respectively. Although yield was not measured, the slower speed of control experienced from spring applications may lead to additional windgrass competition with wheat that may result in a reduction of yield.

SHATTERCANE X ALS-TOLERANT SORGHUM F1 HYBRID AND SHATTERCANE INTERFERENCE IN ALS-TOLERANT SORGHUM. Rodrigo Werle[1], Jared J. Schmidt[1], John Laborde[1], Angela M. Tran*[1], Cody F. Creech[2], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (2)

ALS-resistant grain sorghum cultivars are expected to be available for farmers within the next few years. Knowing that: i) crosses between sorghum and shattercane are likely to occur resulting in gene flow from crop to weed; ii) ALS-susceptible shattercane X ALS-tolerant grain sorghum F1 hybrids (hybrids) were ultimately resistant to ALS herbicides under field conditions; and iii) hybrid fitness is equal to, or greater than, the wild parent, we conducted a greenhouse study to compare the competitive effect of shattercane and hybrid on sorghum, and whether or not herbicide application would influence the competitive ability of the hybrid plants. An additive design was used where weed densities varied while that of crop remained constant. The treatment design was a factorial with two weedy genotypes, shattercane and hybrid, with the hybrid being either exposed or not exposed to an ALS herbicide application (nicosulfuron (26.25 g ai ha$^{-1}$) + rimsulfuron (13.16 g ai ha$^{-1}$)), and five weed densities (0, 1, 2, 3, and 4 plants pot$^{-1}$), in a randomized complete block with four replications. Sorghum density was kept at 1 plant pot$^{-1}$. The study was replicated twice in time. F-tests were performed to compare differences across treatment levels. According to the F-test, shattercane and hybrid produced similar amounts of total above ground biomass across densities, and herbicide exposure did not decrease hybrid biomass production. Moreover, shattercane and the hybrid competed similarly with sorghum, and a herbicide application did not reduce the competitive ability of the hybrid (sorghum biomass yield loss was similar across all treatments). Sorghum wild relatives must be managed by alternate methods before and during the adoption of ALS-tolerant sorghum technology to avoid gene flow and crop yield loss due to competition.

INTERACTIONS BETWEEN FOLIAR APPLIED RYZUP SMARTGRASS TANK MIXED WITH SYNTHETIC AUXIN HERBICIDES IN CORN. Eric J. Ott*[1], James M. Wargo[2], John A. Pawlak[3]; [1]Valent USA Corporation, Greenfield, IN, [2]Valent USA Corporation, Atlanta, GA, [3]Valent USA Corporation, Lansing, MI (3)

RyzUp SmartGrass is a plant growth regulator recently registered for use in corn that contains the active ingredient gibberellic acid ($GA_3$). Gibberellic acid has been demonstrated to cause cell elongation, division, and mitigate crop stress. The application of $GA_3$ occurs between corn growth stages V2 and V5, and since many postemergence (POST) corn herbicide applications take place during this time as well, many questions have been asked about tank-mixing with POST corn herbicides. Very little information is available that has evaluated $GA_3$ at biological effective rates in corn with POST corn herbicides, and no information exists on $GA_3$ at biological effective rates in corn with synthetic auxin herbicides (Group 4). The objective of this experiment was to determine if the addition of $GA_3$ to synthetic auxin herbicides would affect crop response compared to 2,4-D, dicamba, and clopyralid containing herbicides alone. Replicated trials were initiated near Toloun, IL and Union City, OH. Plots were 3 m by 10 m, with three replications. Plots were sprayed with either 2,4-D ester (530 g ai/ha), dicamba + diflufenzapyr (392 g ai/ha), cloplyralid + flumetsulam + acetochlor (1040 g ai/ha) with and without $GA_3$ (14 g ai/ha) at V3 (Toulon, IL), and V4 (Union City, OH) growth stages. The trials were rated 14 days after treatment (DAT) for crop phytotoxicity and at grain harvest for harvestable stand and yield. Data were subjected to ANOVA at $\alpha = 0.05$ level. 2,4-D when tank-mixed with $GA_3$ significantly increased corn phytotoxicity at one location compared to 2,4-D alone. However, the dicamba + diflufenzapyr, and cloplyralid + flumetsulam + acetochlor treatments were not significantly affected by the addition of $GA_3$ in these two trials. No differences were observed in the harvestable stand (percent of untreated) at both locations, even though significant stalk damage (25-33%) occurred at the Union City, OH site due to several strong wind storms. There was no significant difference in corn yield, yet treatments that contained $GA_3$ tended to have numerically greater yields than treatments without $GA_3$. 2,4-D should not be tank-mixed with $GA_3$ for use in corn. Dicamba + diflufenzapyr and cloplyralid + flumetsulam + acetochlor did not increase corn phytotoxicity and appeared to be safe. However, further work is needed to confirm with commonly used hybrids.

### CONTROL OF GLYPHOSATE-RESISTANT GIANT RAGWEED BY TANK MIXING GLUFOSINATE WITH 2,4-D AND/OR DICAMBA IN CORN.

Zahoor A. Ganie*[1], Kevin Watteyne[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Bayer CropScience, Lincoln, NE (4)

Glyphosate-resistant giant ragweed (*Ambrosia trifida*) is a problematic and most competitive weed in corn and soybean. Currently, limited POST herbicide options are available for effective control of glyphosate-resistant giant ragweed. With no glufosinate-resistant broadleaf species reported yet, glufosinate is an alternate option for controlling glyphosate resistant weeds including giant ragweed in glufosinate-resistant corn. The objective of this study was to evaluate efficacy of tank-mixing glufosinate with phenoxy-herbicides for control of glyphosate-resistant giant ragweed. An experiment was conducted in 2013 near Clay Centre, NE in a corn field infested with glyphosate-resistant giant ragweed. The treatments included glufosinate, 2,4-D and dicamba applied alone and in tank-mixes at varying rates. The results revealed tank-mixing glufosinate applied alone or in tank-mix with 2,4-D and/ or dicamba provided greater >90% giant ragweed control at 10, 35 and 65 DAT compared to dicamba or 2,4-D applied alone. All herbicide treatments reduced giant ragweed density and biomass compared to nontreated control, except 2,4-D at 0.28 kg ae $ha^{-1}$. Tank mixing glufosinate and dicamba resulted in corn yield 8620-10519 kg $ha^{-1}$. Results suggested that efficacy of phenoxy-herbicides for control of glyphosate-resistant giant ragweed enhanced when tank mixed with glufosinate compared to alone and among the tank-mixes, glufosinate + dicamba and glufosinate +dicamba + 2,4-D were better than glufosinate + 2,4-D.

### INFLUENCE OF FALL AND EARLY SPRING APPLICATION OF PRE-PACKAGED TANK MIXTURE OF IODOSULFURON AND THIENCARBAZONE-METHYL ON CONTROL OF GLYPHOSATE-RESISTANT GIANT RAGWEED IN NO-TILL CORN.

Simranpreet Kaur*[1], Kevin Watteyne[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Bayer CropScience, Lincoln, NE (5)

A pre-packaged tank mixture of thiencarbazone and iodosulfuron (Autumn™ Super), an ALS-inhibiting herbicide from Bayer Crop Science, is recently registered for winter annual broadleaf and grass weed control in fall or early spring before planting crops including corn and soybean. Glyphosate-resistant giant ragweed (*Ambrosia trifida* L.) is one of the most troublesome weeds in NE. It germinates early in the season and competes with corn and soybean because of early establishment. Management of giant ragweed should include fall or early spring application of herbicides. The objective of this study was to evaluate efficacy of thiencarbazone plus iodosulfuron applied alone or in tank mixes with 2,4-D, dicamba, glyphosate or metribuzin in fall and early spring for control of glyphosate-resistant giant ragweed. Field experiment was initiated with fall herbicide application in 2012 in a field infested with glyphosate-resistant giant ragweed near Clay Center, NE and followed by early spring and in-crop herbicide applications in 2013 in no-till corn. Results suggested that tank mixing thiencarbazone plus iodosulfuron with 2,4-D, dicamba, or metribuzin resulted in reduced giant ragweed emergence (< 4.0 plants $m^{-2}$) compared with treatments without Autumn™ Super. Similar result was reflected at 21 days after early spring herbicide application. For example, Autumn™ Super tank mixed with 2,4-D, dicamba, or metribuzin provided > 95% control of giant ragweed and other winter annuals including tansy mustard, henbit, and field pennycress compared with treatments without Autumn™ Super. A tank mixture of thiencarbazone plus isoxaflutole (Corvus™) with atrazine applied PRE was followed by tembotrione (Laudis™) and atrazine applied POST in no-till corn as a blanket application and growers practice. Periodical observations throughout the growing season revealed that all the treatments with Autumn™ Super tank mixes resulted in ≥ 93% control of giant ragweed.

### CONTROL OF HPPD-RESISTANT WATERHEMP WITH MESOTRIONE AND TANKMIXES APPLIED PREEMERGENCE.

Jon E. Scott*[1], Aaron S. Franssen[2], Stevan Z. Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Syngenta Crop Protection, Seward, NE (6)

Waterhemp (*Amaranthus tuberculatus syn. rudis*) is identified as one of the most problematic weed species for the row-crop production in the Midwestern United States in the last 20 years. Waterhemp populations have been confirmed to be resistant to six mechanism of actions including ALS, PSII, PPO, Glycines, HPPD, and Synthetic auxins-inhibiting herbicides. A waterhemp population was found to be resistant to post-emergent application of HPPD-inhibiting herbicides in Nebraska. Therefore, field bioassays were conducted in 2012 and 2013 to determine the control of HPPD-resistant waterhemp with pre-emergent application of mesotrione alone at five rates (0, 95, 190, 380, and 760 g ai/ha), mesotrione at the five rates tankmixed with metolachlor (1880 g ai/ha) and atrazine (700 g ai/ha), and Lumax® (*s*-metolacholor+mesotrione+atrazine) at 940+95+350, 1880+190+700, 3760+380+1400, and 7520+760+2800 g ai/ha, respectively. Weed control was visually evaluated at 20, 30, 40 and 50 DAT, and weed dry matter was recorded. Dose response curves were described for mesotrione, mesotrione tankmix, and Lumax; these were further utilized to determine $ED_{50}$, $ED_{60}$, and $ED_{80}$ values for control of HPPD-resistant waterhemp. The level of resistance to mesotrione alone and mesotrione tankmixed with fixed rates of metolachlor and atrazine at 50 DAT was 6 and 10 times the label rate, respectively. These results indicate that HPPD-resistant waterhemp is also resistant to preemergene applications of mesotrione.

### CONTROL OF HPPD-RESISTANT WATERHEMP IN CORN AND SOYBEAN.

Jon E. Scott*[1], Aaron S. Franssen[2], Stevan Z. Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Syngenta Crop Protection, Seward, NE (7)

Waterhemp (*Amaranthus tuberculatus syn. rudis*), an early germinating summer annual, has been confirmed to be resistant to one or more of glycine, synthetic-auxins, PSII, ALS, PPO and HPPD-inhibiting herbicides. Field experiments were conducted in corn and soybean cropping systems in 2013 to evaluate the control of HPPD-resistant waterhemp with premergence (PRE), postemergence (POST), and PRE followed by POST applications. PRE applications of *s*-metolachlor + atrazine + mesotrione with acetochlor provided 99% control at 61 DAT. Also, pyroxasulfone + saflufenacil + atrazine provided 97% control at 61 DAT. Postemergence herbicides including glyphosate, and combinations of mesotrione + atrazine with dicamba, glufosinate or metribuzin provided good control at 41 DAT. All combinations of PRE applications of *s*-metolachlor + atrazine + mesotrione followed by POST applications of dicamba, glyphosate or glufosinate mixtures provided complete control 29 days after the POST application. PRE applications of thiencarbozone-methyl + isoxaflutole and atrazine followed by POST applications of synthetic auxins provided 97% control 29 days after the POST treatment. For soybeans, PRE applications of s-metolachlor + metribuzin, s-metolachlor + fomesafen, flumioxazin + pyroxasulfone, pyroxasulfone + saflufenacil, and chloransulam-methyl + sulfentrazone provided ≥91% control 26 DAT. PRE applications of *s*-metolachlor + metribuzin or chloransulam-methyl + sulfentrazone followed by fomesafen + glyphosate, or s-metolachlor + fomesafen followed by glyphosate or glufosinate provided greater than 99% control 21 days after the POST application.

### WEED HEIGHT AND THE INCLUSION OF ATRAZINE INFLUENCE CONTROL OF MULTIPLE-RESISTANT PALMER AMARANTH WITH HPPD-INHIBITORS.

Jonathon R. Kohrt*, Christy L. Sprague; Michigan State University, East Lansing, MI (8)

Glyphosate/ALS-resistant Palmer amaranth has been identified in nine Michigan counties. While this weed is more prevalent in soybean fields, it is becoming an increasing problem in corn. A field experiment was conducted near Middleville, MI in 2013 to evaluate the effect of weed height and the inclusion of atrazine to HPPD inhibitors on multiple-resistant Palmer amaranth control. Herbicide treatments included: atrazine (560 g/ha) + COC (1% v/v), mesotrione (105 g/ha) + COC (1% v/v), topramezone (18 g/ha) + MSO (1% v/v), and tembotrione (92 g/ha) + MSO (1% v/v) applied alone and the HPPD inhibitors in combination with atrazine. Applications were made when Palmer amaranth height was 8 and 15 cm tall. Weed control was assessed at 7 and 21 days after treatment (DAT), and weed biomass was harvested, 21 DAT. Palmer amaranth control was affected by the height at application and by the inclusion of atrazine to the HPPD-inhibiting herbicides. Palmer amaranth control was greater and more biomass was reduced when herbicide applications were made to 8 cm tall Palmer amaranth. In most cases, the addition of atrazine to the HPPD inhibitors increased control of Palmer amaranth over the HPPD inhibitors alone at both application timings. At 21 DAT, the only treatments that provided greater than 90% Palmer amaranth control were the combinations of atrazine with mesotrione, topramezone, or tembotrione at the 8 cm timing. This research suggests that the optimal timing for effective postemergence control of Palmer amaranth is 8 cm or less with the use of an HPPD inhibitor in combination with atrazine.

## CORN YIELD AS INFLUENCED BY NITROGEN MANAGEMENT, RESIDUAL HERBICIDE, AND OTHER PEST MANAGEMENT INPUTS. John T. Buol*, Rebecca R. Bailey, Elizabeth J. Bosak, Tim Trower, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (9)

Fertilizer, herbicide, and other pesticide inputs play a large role in Wisconsin agriculture. In 2012, farms across the state spent $880 million on fertilizers and another $300 million on chemical pesticides. Field experiments were conducted at the University of Wisconsin Arlington Research Station in 2012 and 2013 to determine what combination of nitrogen (N) rates and pesticide inputs result in the greatest corn yields. Ten treatments were arranged in a randomized complete block design with six replications in 2012 and four replications in 2013. The treatment structure was a two-way factorial with two levels of N (207 kg N ha$^{-1}$ or 151 kg N ha$^{-1}$) and five levels of pesticide input. All five pesticide levels (PL) of pesticide input included postemergence (POST) glyphosate applied at V6 corn growth stage at the rate of 0.87 kg a.e. ha$^{-1}$ plus 2.8 kg ha$^{-1}$ ammonium sulfate. PL-1 included no further pesticide input; PL-2 included a preemergence (PRE) herbicide application of dimethenamid-P at 1.1 kg ha$^{-1}$; PL-3 included a PRE application of 0.66 kg ha$^{-1}$ dimethenamid-P plus 0.07 kg ha$^{-1}$ saflufenacil; PL-4 was the same as PL-3 but included a tank-mix of 0.35 kg ha$^{-1}$ dicamba plus diflufenzopyr in the V6 POST application, and PL-5 was the same as PL-4 but included a tank-mix of 0.05 kg ha$^{-1}$ fluxapyroxad and 0.1 kg ha$^{-1}$ pyraclostrobin fungicides in the V6 POST application, and subsequently received a second POST application of 0.1 kg ha$^{-1}$ pyraclostrobin plus 0.04 kg ha$^{-1}$ metconazole fungicide at R1 corn growth stage. Plots were 3 m wide by 15 m long and all pesticide applications were applied with a backpack sprayer with water for a total of 140 L ha$^{-1}$ carrier volume. Corn yield data were subjected to ANOVA. In a full model including year (Y), nitrogen level (N), and pesticide input level (PL) as fixed effects, no third order or second order interactions were significant at ($P < 0.1$). The main effects Y and N were significant at $P < 0.0001$ and $P = 0.004$, respectively, but the main effect of PL was not significant ($P = 0.31$). Given these results, a subsequent model was analyzed with Y set as a random effect and N and PL fixed effects. Subsequently, N by PL interaction was again not significant ($P = 0.65$). There was a significant difference in corn yield based on N over the two years ($P < 0.0001$) where the high rate produced 14,290 kg ha$^{-1}$ versus 13,650 kg ha$^{-1}$ produced at the low rate. Yield for the five levels of PL in increasing order (i.e. PL-1, PL-2, PL-3, PL-4, and PL-5) was 13,620, 13,770, 14,250, 13,940, and 14280 kg ha$^{-1}$ corn yield, respectively, but these were not considered significantly different ($P=0.15$). In conclusion, additional N increased corn yield each year but was not influenced by increasing levels of pesticide inputs, specifically herbicide and fungicide inputs. Whether or not the increased rate of N was warranted would depend on economic evaluation of corn and N price, but the focus of this study was to investigate the idea of whether interactions with other inputs were observed, and that did not appear to be the case. These results are likely impacted by the fact that pest pressures (weeds and diseases) were not present at levels significant enough to cause a yield reduction if application did not occur. We also did not measure weed density at the time of POST application, which may have provided evidence that the additional residual herbicide input was valuable for glyphosate resistance management. However, according to the analysis of the corn yield alone, increasing levels of pesticide input should only be used as a sound integrated pest management program, and not for prophylactic treatments to increase grain yield.

## COVER CROP RESPONSE TO CORN AND SOYBEAN RESIDUAL HERBICIDES. Chris P. Corzatt*, Mark L. Bernards; Western Illinois University, Macomb, IL (10)

Cover crops are becoming more widely used in corn and soybean rotations because of the benefits they provide for erosion control, weed suppression, and soil fertility. Data are available that describe herbicide degradation in the soil over time and rotation restrictions are described for many commonly grown crops. But there is little data on how some important cover crop species will respond to carryover levels of PRE and POST herbicides. The objective of this research was to evaluate the response of ten cover crop species to thirteen corn and soybean herbicides. Winter wheat (53 kg ha$^{-1}$), cereal rye (65 kg ha$^{-1}$), winter rapeseed (3 kg ha$^{-1}$), red clover (7 kg ha$^{-1}$), Austrian winter pea (58 kg ha$^{-1}$), hairy vetch (9.7 kg ha$^{-1}$), radish (6 kg ha$^{-1}$), crimson clover (2.6 kg ha$^{-1}$), annual ryegrass (1.2 kg ha$^{-1}$), and turnip (1.3 kg ha$^{-1}$) were planted on October 9, 2013 in 30 inch rows. The following herbicides were applied on October 4, 2013 at four levels, the labeled rate and 50%, 25%, and 12.5% of the labeled rate (listed following the active ingredient in g ha$^{-1}$): pyroxasulfone (240, 120, 60, 30), chlorimuron-ethyl (17.5, 8.8, 4.4, 2.2), flumioxazin (107, 53.5, 26.8, 13.4), cloransulam methyl (35.3, 17.7, 8.8, 4.4), fomesafen (329, 165, 82, 41), sulfentrazone (420, 210, 105, and 53), 2,4-D amine (1120, 560, 280, 140), dicamba (1120, 560, 280, 140), mesotrione (210, 105, 53, 26), isoxaflutole (48, 24, 12, 6), atrazine (1120, 560, 280, 140), sulfentrazone+chlorimuron-ethyl (420+52.5, 210+26, 105+13, 53+6), and thiencarbazone-methyl+tembotrione (7.5+37.8). We obtained inconsistent stands of crimson clover, annual ryegrass, red clover, and hairy vetch and will not report data on those species. Our data will be reported with the following scale for cover crop response to the full rate of injurious herbicides: Severe: >40% damage, Moderate: 20-40% damage, Slight: 1-20% damage, None: 0% damage. Wheat and cereal rye showed slight to no damage from any of the herbicides applied. The mustard species were the most sensitive species tested. Injury to radish was severe when treated with dicamba, fomesafen, isoxaflutole, mesotrione, sulfentrazone, or sulfentrazone+chlorimuron-ethyl; moderate when treated with chlorimuron; and slight when treated with atrazine or tembotrione+thiencarbazone-methyl. Injury to winter rape was severe when treated with dicamba, isoxaflutole, or mesotrione; moderate when treated with chlorimuron ethyl or sulfentrazone; and slight when treated with fomesafen or tembotrione+thiencarbazone methyl. Injury to turnip was severe when treated with cloransulam, fomesafen, isoxaflutole, mesotrione, sulfentrazone or sulfentrazone+chlorimuron-ethyl ; moderate when treated with chlorimuron-ethyl or dicamba; and slight when treated with atrazine or tembotrione+thiencarbazone-methyl. Injury to field pea was severe when treated with dicamba, mesotrione, or sulfentrazone+chlorimuron-ethyl; and slight when treated with chlorimuron-ethyl, fomesafen or sulfentrazone. Injury was slight when herbicides were applied at 12.5% of labeled rate, which represents 3 half-lives for each specific product.

## ITALIAN RYEGRASS, *LOLIUM MULTIFLORUM* AND OTHER COVER CROPS FOR SUPPRESSION OF SOYBEAN CYST NEMATODE, *HETERODERA GLYCINES*.. Bruce A. Ackley*, Steven K. Harrison, Mark Sulc; The Ohio State University, Columbus, OH (11)

Soybean cyst nematode (SCN; *Heterodera glycines*) causes more economic damage to U.S. soybean producers than any other soybean pathogen. Previous work has shown that Italian ryegrass (IR) significantly reduced SCN populations in soil under greenhouse and field conditions, but the nature and extent of this suppressive effect on SCN is not well understood. My research focused on investigating the nature of the Italian ryegrass x SCN interaction and the effectiveness of Italian ryegrass as a winter cover crop compared to other forage species' ability to suppress SCN. Overall results showed that after two years of growing susceptible soybean in heavily SCN-infested plots, all winter annual cover crops tested were generally effective in preventing an increase in SCN population growth. Furthermore, my research indicated that an IR cover crop planted in early autumn after soybean significantly reduced SCN population density in soil and was significantly more effective in reducing SCN egg population densities than oat or rye cover crops. Thus incorporation of IR into soybean cropping systems as a winter annual cover crop has the potential to be a useful SCN management tactic for producers.

## LIGHT INTERCEPTION OF SOYBEAN AS INFLUENCED BY ROW WIDTH, SEEDING RATE, AND WEED COMPETITION. Thomas R. Butts*[1], Jason K. Norsworthy[2], Greg R. Kruger[3], Lowell Sandell[4], Bryan G. Young[5], Kevin W. Bradley[6], Lawrence E. Steckel[7], Mark M. Loux[8], Vince M. Davis[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Arkansas, Fayetteville, AR, [3]University of Nebraska-Lincoln, North Platte, NE, [4]University of Nebraska-Lincoln, Lincoln, NE, [5]Southern Illinois University, Carbondale, IL, [6]University of Missouri, Columbia, MO, [7]University of Tennessee, Jackson, TN, [8]The Ohio State University, Columbus, OH (12)

Soybean light interception (LI) is vital for plant growth, weed suppression, and yield development in today’s agricultural production systems. A field study was conducted through cooperative effort with 7 universities in 9 different locations to observe the effect of soybean row width and seeding rate, along with herbicide strategies, on soybean LI. Data presented are from the Arlington, Wisconsin location only. Two row widths (38 and 76 cm), three seeding rates (173,000, 322,000, and 470,000 seeds ha$^{-1}$), and two herbicide strategies (preemergence plus postemergence (PRE + POST) vs. POST-only) were arranged in a randomized complete block split-plot design with row width as the main plot factor and a 3x2 factorial of seeding rate and herbicide strategies as the subplots. PRE applications were made 1 day after planting. POST-only applications were made 23 days after emergence (DAE) and POST applications following PRE were made 42 DAE. Digital images were taken weekly from 19 to 75 DAE and analyzed to provide weekly LI percentages. Third degree polynomial equations were estimated for each treatment’s LI percentages over time and the area underneath each curve was integrated to create LI values. LI integrations from 26, 33, and 40 DAE (V2-R1 soybean growth stages) were summed for each treatment to form a cumulative LI value to correspond with the critical weed free period for soybean. Cumulative LI was positively correlated with yield ($R^2 = 0.3008$) and negatively correlated with weed counts at soybean harvest including *Amaranthus powelli* ($R^2 = 0.0945$) and *Setaria faberi* ($R^2 = 0.0945$). The highest seeding rate significantly increased cumulative LI ($P<0.0001$). A significant interaction was found between row width and herbicide strategy ($P=0.0110$) with increased cumulative LI when using 38 cm rows and a PRE + POST herbicide strategy. The treatment with the highest cumulative LI (38 cm row width, 470,000 seeds $ha^{-1}$, PRE + POST) achieved 24% more LI ($P=0.0138$) than the next highest treatment (38 cm row width, 322,000 seeds $ha^{-1}$, PRE + POST) and 297% more LI ($P<0.0001$) than the lowest treatment (78 cm row width, 173,000 seeds $ha^{-1}$, PRE + POST). The treatment with the highest cumulative LI also had the highest overall yield (4540 kg $ha^{-1}$); however it was not statistically different from eight other treatments at $P<0.05$, including the treatment that recorded the lowest cumulative LI. Cumulative LI exhibited a slight positive correlation with yield and negative correlation with weed counts at soybean harvest which may suggest a connection with the critical weed free period of soybean and the potential for end-of-season weed escapes. More replication in space and time are needed to support these conclusions so this experiment will be repeated in 2014 and analyzed over all locations.

## WEED MANAGEMENT WITH FLUMIOXAZIN PLUS PYROXASULFONE IN SOYBEAN. Nader Soltani*, Christy Shropshire, Peter H. Sikkema; University of Guelph-Ridgetown, Ridgetown, ON (13)

Eleven field experiments were conducted over a three-year period (2010, 2011, and 2012) in conventional- and no-till soybean using a flumioxazin and pyroxasulfone premix. The labeled use rates of flumioxazin/pyroxasulfone in soybean are 160 (flumioxazin at 71 g ai $ha^{-1}$ plus pyroxasulfone at 89 g ai $ha^{-1}$) and 200 (flumioxazin at 88 g ai $ha^{-1}$ plus pyroxasulfone at 112 g ai $ha^{-1}$) g ai $ha^{-1}$ for course to medium and fine textured soils, respectively. Preemergence and preplant applications were evaluated for soybean injury, weed control, and yield compared to standard herbicides. Early-season soybean injury from flumioxazin/pyroxasulfone ranged from 1 to 19%; however by harvest, soybean yields were similar across labeled rates (160 and 200 g ai $ha^{-1}$), standard treatments, and the untreated control. Flumioxazin/pyroxasulfone provided excellent control (99 to 100%) of velvetleaf, pigweed species, and common lambsquarters across almost all rates tested (80 to 480 g ai $ha^{-1}$). Common ragweed, green foxtail, and giant foxtail control increased with flumioxazin/pyroxasulfone rate. The biologically effective rates varied between tillage systems. The flumioxazin/pyroxasulfone rate required to provide 80% control ($R_{80}$) of pigweed was 3 and 273 g ai $ha^{-1}$ under conventional- and no-till, respectively. For common ragweed, the $R_{80}$ was 158 g ai $ha^{-1}$ under conventional tillage; yet, under no-till, the rate was non-estimable. The results indicate that flumioxazin/pyroxasulfone can provide effective weed control as a set-up for subsequent herbicide applications.

## THE INFLUENCE OF HERBICIDE RATE AND APPLICATION TIMING ON THE SOIL-RESIDUAL EFFICACY OF PREPLANT SOYBEAN HERBICIDES. R. Joseph Wuerffel*[1], Bryan G. Young[1], Julie M. Young[1], Mark L. Bernards[2], Aaron G. Hager[3]; [1]Southern Illinois University, Carbondale, IL, [2]Western Illinois University, Macomb, IL, [3]University of Illinois, Urbana-Champaign, IL (14)

Proper herbicide application timing for both soil-residual and foliar-applied herbicides is essential to maximize herbicide efficacy. Early burndown applications in the spring are performed to control problematic winter annual weeds such as horseweed when they are small. Commonly, these applications will also include soil-residual herbicides for control of summer annuals, especially in soybeans [*Glycine max* (L.) Merr.], for control of glyphosate-resistant waterhemp (*Amaranthus tuberculatus*). The extent to which preplant herbicide application timing, herbicide rate (full or reduced), and combinations thereof, influence the efficacy of preplant soil-residual applications targeting waterhemp must be described for the development of best management practices. Therefore, the objective of this research was to investigate the efficacy of several preplant, soil-residual soybean herbicides on waterhemp when applied at 0, 14, and 28 days before planting (DBP), at full and reduced rates. In 2011 and 2012, field experiments were conducted in two soybean fields near DeSoto and Champaign, IL evaluating the efficacy of five commonly used preplant, soybean herbicide combinations: flumioxazin plus chlorimuron, sulfentrazone plus cloransulam, sulfentrazone plus chlorimuron, fomesafen plus *s*-metolachlor, and pendimethalin plus saflufenacil, applied at full and/or reduced commercial use rates at the aforementioned timings. The efficacy of preplant soil-residual herbicides, applied at full and reduced rates, was affected by application timing more so than rate; nevertheless, applications made at 14 or 28 DBP benefited from full rates over reduced rates three weeks after planting. In 2011, applications made at 14 and 28 DBP resulted in a 26 and 41% loss in efficacy three weeks after planting, respectively, averaged over all herbicide combinations. Similar, but less pronounced, reductions in the efficacy of soil-residual herbicides were observed in 2012 following the 14 and 28 DBP applications, with 5 and 26% reductions in efficacy, respectively. Overall, this research provides justification to recommend that residual herbicides targeting waterhemp should be applied as close to soybean planting as possible, regardless of application rate. In addition, management of horseweed should still be performed earlier in the spring with a separate herbicide application when plants are small.

## OPTIMUM GLYPHOSATE APPLICATION TIMING IN SOYBEAN AS INFLUENCED BY PREEMERGENCE RESIDUAL HERBICIDE USE FOLLOWING DIFFERENT PLANTING DATES. Ryan P. DeWerff*, Vince M. Davis, Shawn P. Conley; University of Wisconsin-Madison, Madison, WI (15)

The current trend in Midwest soybean production is to plant earlier in the growing season. Soybean area planted by early May has increased nationally from 9% in 1981 to 31% in 2011 according to the USDA-NASS. Several recent research reports support this practice by indicating soybean yield can be increased by planting earlier. Planting date may also affect weed management decisions, and there are limited research reports investigating this. Earlier planting dates subject the crop to weed competition for longer durations of time, which may impact the optimum timing of a single postemergence (POST) glyphosate application. Additionally, more intensive early-season weed control strategies, such as using a preemergence (PRE) residual herbicide, may be necessary for adequate weed control and yield maximization. To test these hypotheses, a field experiment was conducted in 2012 and 2013 at the University of Wisconsin Arlington Research Station to determine weed control and soybean yield as influenced by PRE residual herbicide use and POST glyphosate application timing following three different planting dates. Plots were planted in the last week of April, the second week of May and the first week of June, to represent early, mid, and late planting dates, respectively. A PRE application of 0.26 kg a.i. ha$^{-1}$ sulfentrazone plus 0.03 kg a.i. ha$^{-1}$ cloransulam-methyl was applied to half of the plots following each planting date. Glyphosate at 0.87 kg a.e. ha$^{-1}$ was applied POST to all plots at the V1, V2, V4, or R1 soybean growth stage. Weed density and heights were measured prior to each respective glyphosate application and prior to soybean harvest. The dominant weed species in the study were common lambsquarters *(Chenopodium album),* common ragweed *(Ambrosia artemisiifolia),* giant foxtail *(Setaria faberi),* and large crabgrass *(Digitaria sanguinalis).* The optimum time to apply glyphosate was influenced by both planting date and residual herbicide use in 2012 ($P<0.0001$). When a residual herbicide was used, there was no significant difference in soybean yield among the different glyphosate timings regardless of planting date. In the absence of a residual, yield was maximized at the early planting date when POST glyphosate applications were made at the V1 or V2 growth stages. No significant differences in yield were observed between application timings at the mid and late planting dates. The optimum timing of a POST glyphosate application was highly variable in our experiment and was potentially influenced by weather. In the hot, dry early season conditions of 2012, delaying POST applications until V4 or R1 reduced yield at the early planting date. Under the cooler, wetter environment of 2013, delaying application until R1 did not significantly reduce soybean yield in any of the planting dates, possibly due to the lack of competition for water. While the use of a residual herbicide and planting date did not significantly impact yield under most scenarios in our experiment, it has implications on herbicide resistance management. The use of a residual herbicide, and delayed planting date, significantly reduced the amount of weeds exposed to the POST glyphosate application ($P = 0.0012$). Averaged across years and glyphosate timings, total weed densities exposed to the POST application were 24 m$^{-2}$, 13 m$^{-2}$, and 4 m$^{-2}$ for the early, mid, and late planting dates, respectively, when a PRE residual herbicide was used. In the absence of a PRE residual, total weed densities averaged 161 m$^{-2}$, 92 m$^{-2}$, and 15 m$^{-2}$ for the early, mid, and late planting dates, respectively. In conclusion, there is a trade-off between planting date and residual herbicide use for resistance management, where earlier planting may place greater reliance on a residual herbicide for reducing POST herbicide exposure.

CONTROL OF GLYPHOSATE-RESISTANT COMMON WATERHEMP WITH LONG CHAIN FATTY ACID INHIBITORS APPLIED IN A SPLIT APPLICATION IN SOYBEANS. Debalin Sarangi*[1], Lowell Sandell[1], Stevan Z. Knezevic[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE (16)

Glyphosate-resistant common waterhemp (*Amaranthus rudis* Sauer) is one of the most encountered and troublesome weeds in corn and soybean fields in mid-western United States. Common waterhemp has a rapid growth habit and extended seedling emergence; therefore, late emerging flushes cannot be controlled by PRE-applied or early POST-applied herbicides. Several long chain fatty acid inhibiting herbicides having good soil residual activity, have been registered that can be applied POST in soybean. Field experiment was conducted in Dodge County, NE to evaluate efficacy of long chain fatty acid (LCF) inhibiting herbicides applied at a recommended full rate or in a split application for control of glyphosate-resistant common waterhemp. The results suggested that acetochlor applied PRE at recommended full rate (3.36 kg ai ha$^{-1}$) resulted in 95% control of common waterhemp at 15 d after treatment (DAT) and it reduced weed density as low as ≤ 7 m$^{-2}$ compared to other LCF-inhibiting herbicides applied at full rate. At the initial stage sequential application of herbicides at reduced rate was not as effective as the full application rates and most of the split application did ≤ 81% weed control. Throughout the experiment, acetochlor applied at full rate or in a split application and pyroxasulfone at full rate resulted in > 90% control of common waterhemp and at harvest acetochlor in two splits and pyroxasulfone at full dose reduced the weed biomass by ≥ 97% over untreated control. Though these treatments were better in weed control, they did not result in significantly higher soybean yield compared to other herbicide treatments. A single application of LCF inhibiting herbicides as PRE at full rate resulted in similar or better control of glyphosate-resistant common waterhemp and soybean yield.

---

DICAMBA IN A RESIDUAL SYSTEM FOR GLYPHOSATE-RESISTANT WATERHEMP CONTROL IN SOYBEAN. Seth T. Logan*[1], Bryan G. Young[2], Julie M. Young[2], Simone Seifert-Higgins[3], Sara M. Allen[4]; [1]Monsanto, Tamaroa, IL, [2]Southern Illinois University, Carbondale, IL, [3]Monsanto Company, St. Louis, MO, [4]Monsanto, Bonnie, IL (17)

Soybean production in recent years has become increasingly more difficult due to the prevalence of hard-to-control and glyphosate-resistant weeds such as waterhemp. Glyphosate-resistant waterhemp has quickly grown to become one of the most problematic weeds in soybean production today and the lack of effective herbicides in soybean for management presents an increasingly difficult challenge for soybean producers. The potential future use of dicamba in dicamba-tolerant soybeans will provide an additional herbicide to gain more effective control of problematic weeds such as waterhemp in both preplant and postemergence applications. The foliar activity of dicamba on waterhemp may not be the only benefit from a dicamba tolerant soybean system as some soil residual activity of dicamba may be evident on waterhemp, subject to weather conditions and rainfall. In 2012 and 2013 experiments were established on glyphosate-resistant waterhemp populations in Desoto and Murphysboro, IL to evaluate the efficacy of preemergence applications of dicamba and 2,4-D. Both locations had a silt loam soil type with organic matter of 1.8 to 2.1% and a cation exchange capacity ranging from 6 to 12. Herbicides were applied to weed-free, no-till sites. In 2012 the Desoto site received only 1.82 cm cumulative rainfall with the Murphysboro site receiving just 1.08 cm of rainfall up to six weeks after application. Under these low rainfall conditions applications of dicamba applied at (0.56 kg ae/ha) provided 95 to 99% control of glyphosate-resistant waterhemp at 21 DAT with an experimental 2,4-D choline formulation applied at 0.84 kg ae/ha providing 92 to 96% control. Furthermore, under these dry conditions, these same applications of dicamba provided 41 to 83% control at 56 DAT while experimental 2,4-D choline provided 20 to 54% control of glyphosate-resistant waterhemp. In 2013 these same experiments were performed at the Desoto and Murphysboro locations with the Desoto site receiving 18 cm of rainfall up to six weeks after application and the Murphysboro location receiving 16 cm of rainfall with 5 cm of that rainfall coming within 3 days after application. Under moderate early rainfall conditions (Desoto 2013) dicamba provided twice as much (50 to 80%) control of glyphosate-resistant waterhemp 21 DAT than 2,4-D (18 to 38%). Under very heavy early rainfall conditions (Murphysboro 2013) control of glyphosate-resistant waterhemp was less than 20% at 14 DAT for either herbicide. This research suggests dicamba has the potential to contribute some level of residual waterhemp control. Rainfall patterns after dicamba application dramatically influence the residual activity of dicamba and additional experiments will be conducted to further characterize the soil residual benefits of dicamba in a dicamba tolerant soybean system.

## RESPONSE OF GLYPHOSATE-RESISTANT HORSEWEED TO POST HERBICIDES.

Joseph D. Bolte*, Reid J. Smeda; University of Missouri, Columbia, MO (18)

Horseweed (*Conyza canadensis*) is found commonly in agricultural production fields throughout the mid-west. In many locations, populations resistant to glyphosate and other herbicides are common, complicating management in soybean. Recent development of dicamba and 2,4-D offer a new option for in-crop POST control. Field trials in 2013 were established in two locations in Missouri, Novelty and Portageville, to determine the POST efficacy of 2,4-D and dicamba on glyphosate-resistant horseweed. In the absence of any crop, herbicide applications were applied at three different plant heights including: 10 to 20; 20 to 30; 30 to 40 cm. Treatments included glyphosate alone at 839 g ae/ha, three rates of 2,4-D (560, 841 g and 1,121 g ae/ha) plus glyphosate, and three rates of dicamba (420, 560 and 841 g ae/ha) plus glyphosate. At 35 days after treatment (DAT), visual injury (0=no injury and 100=complete control) and plant dry weights were recorded. Plant response to glyphosate alone was poor for all treated sizes of horseweed, with visual control ranging from 10 to 42%. POST control of horseweed increased with increasing rates of both 2,4-D and dicamba, but decreased as treatment plant size increased. For 2,4-D, horseweed control ranged from 68 to 100%, 33 to 83% and 39 to 75% for the 10 to 20, 20 to 30, and 30 to 40 cm plants, respectively. With dicamba, horseweed control ranged from 89 to 98%, 68 to 88%, and 79 to 84% for the 10 to 20, 20 to 30, and 30 to 40 cm plants, respectively. Differences in horseweed control were noted between locations and were likely attributed to initial horseweed density; 42 plants $m^{-2}$ and 8.3 plants $m^{-2}$ at Novelty and Portageville, respectively. Horseweed dry weights were reduced up to 31, 43 and 62% for 2,4-D at 10 to 20, 20 to 30, and 30 to 40 cm plants. With dicamba, horseweed dry weight was reduced 45, 39, and 59% at the respective treated sizes. Results indicate that visual control of horseweed with 2,4-D and dicamba was more effective on smaller (10 to 20 cm) treated plants. Although visual control of horseweed was greater with dicamba compared to 2,4-D at the rates applied, reductions in plant biomass (as a % of control) were similar between growth regulator herbicides.

## ENLIST SOYBEAN TOLERANCE TO ENLIST DUO.

Jeff M. Ellis*[1], David C. Ruen[2], Eric F. Scherder[3], David M. Simpson[4], Scott C. Ditmarsen[5]; [1]Dow AgroSciences, Smithville, MO, [2]Dow AgroSciences, Lanesboro, MN, [3]Dow AgroSciences, Huxley, IA, [4]Dow AgroSciences, Indianapolis, IN, [5]Dow AgroSciences, Madison, WI (19)

Previous research with Enlist™ soybean across the Mid-South and Midwest, from 2008 through 2012, demonstrated robust tolerance to 2,4-D when applied preemergence or postemergence. In 2012 and 2013, trials were initiated to evaluate injury to Enlist E3™ soybean following applications of Enlist Duo™ herbicide, a proprietary blend of 2,4-D choline and glyphosate, applied at 2185 and 4370 g ae/ha, 2,4-D choline 1065 and 2130 g ae/ha, glyphosate 1120 and 2240 g ae/ha, glufosinate 542 and 1084 g ae/ha and 2,4-D choline + glufosinate at 1065 + 542 and 2130 + 1084 g ae/ha. Single herbicide treatments were applied at V6 and R2 growth stages. Enlist E3 soybean demonstrated robust tolerance to 2,4-D choline, glyphosate and Enlist Duo across all application timings and rates. Regardless of rate or application timing, injury averaged less that 1% for 2,4-D choline and glyphosate. For Enlist Duo, overall injury with 2815 g ae/ha was 5% or less at any single application timing seven days after treatment. At the 4370 g ae/ha rate, initial injury increased slightly over the 2185 g ae/ha rate yet was negligible by 14 DAT. At seven days after treatment, single applications of glufosinate applied at either V6 or R2, injury averaged 3-4% and 9-10% for 542 and 1084 g ae/ha, respectively. The addition of 2,4-D choline to glufosinate resulted in an 1-2% increase in crop response compared to glufosinate applied alone. Injury observed at seven days after treatment with either glufosinate or 2,4-D choline + glufosinate averaged less than 5% by 14 DAT.

®™Trademark of The Dow Chemical Company (“Dow”) or an affiliated company of Dow. Regulatory approvals are pending for the Enlist™ herbicide solution and crops containing Enlist herbicide tolerance traits. The information presented here is not an offer for sale. Always read and follow label directions. ©2013 Dow AgroSciences LLC

Enlist E3 soybeans are a joint development of Dow AgroSciences and MS Technologies.

## PALMER AMARANTH CONTROL PROGRAM IN ENLIST SOYBEAN.

Kristin Rosenbaum*[1], Jeff M. Ellis[2], Brad Hopkins[3], Jonathan Siebert[4]; [1]Dow AgroSciences LLC., Lincoln, NE, [2]Dow AgroSciences, Smithville, MO, [3]Dow AgroSciences LLC., Indianapolis, IN, [4]Dow AgroSciences, Leland, MS (20)

Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri S. Wats.*) has been reported in corn and soybean fields in Kansas, Michigan, Ohio, Illinois, Indiana, Iowa, and Central Missouri since 2011. Previous research on glyphosate resistant Palmer amaranth in the South has demonstrated the need to include residual herbicides as part of the weed control program. Research was initiated in an Enlist™ Weed Control System to characterize Palmer amaranth control in the Midwest. Four studies were conducted in the Midwest in 2013 to characterize the level of Palmer amaranth control from sequential postemergence (POST) applications of Enlist Duo™ herbicide (2,4-D + glyphosate) at 1640 and 2185 g ae/ha, glufosinate at 542 g ae/ha, 2,4-D + glufosinate at 800+542 and 1065+542 or glyphosate at 1680 g ae/ha. Flexstar GT (fomesafen + glyphosate) at 1380 g ae/ha followed by (fb) glufosinate at 542 g ae/ha was added for comparison. Initial POST applications were made to 2-4 inch Palmer amaranth and a second application made 14 days later when Palmer amaranth averaged less than 6 inches tall. Results 2-3 weeks following the second POST application indicate that sequential applications of 2,4-D + glufosinate, 2,4-D + glufosinate fb Enlist Duo and Enlist Duo fb 2,4-D + glufosinate provided greater than 95% control of Palmer amaranth. Sequential applications of Enlist Duo at 1640 and 2185 g ae/ha provided 72 and 87% Palmer amaranth control, respectively. Glufosinate fb glufosinate provided 89% control and Flexstar GT + glyphosate provided 71% Palmer amaranth control. Palmer amaranth germinates throughout the growing season and has rapid growth during the season. Weed control programs that contain residual herbicides with multiple modes of action and control early season flushes of weeds are recommended over POST only programs. A total of five studies were conducted in 2013 in the Midwest to evaluate weed control delivered by a systems approach composed of a preemergence (PRE) fb POST herbicide applications. PRE foundation treatments consisted of cloransulam + sulfentrazone, flumioxazin + cloransulam, or *S*-metolachlor + fomesafen herbicide products. Initial POST treatments were Enlist Duo at 1640 and 2185 g ae/ha, glufosinate at 542 g ae/ha, 2,4-D + glufosinate at 800 + 542 and 1065 + 542 g ae/ha, and glyphosate at 1120 g ae/ha applied to 2-4 inch Palmer amaranth or approximately 30 days after soybean planting. A second POST application of Enlist Duo at 2185 g ae/ha was applied to select treatments 14 days following the initial POST application. PRE foundation treatments fb POST applications of Enlist Duo or glufosinate +/- 2,4-D fb Enlist Duo provided 95% Palmer amaranth control 2-3 weeks following the second POST application. A PRE treatment fb single POST application of Enlist Duo or glufosinate provided 86 to 90% Palmer amaranth control while the addition of 2,4-D to glufosinate increased control to 93% control or greater for the same program approach. Overall, a program including a PRE fb two POST applications provided 0 to 17% greater Palmer amaranth control when compared to PRE fb single POST programs.

IN-SEASON WEED CONTROL IN DICAMBA-RESISTANT SOYBEAN SYSTEMS FOR CONTROLLING GLYPHOSATE RESISTANT AND OTHER TOUGH TO CONTROL WEEDS. Jeffrey Golus*[1], Lowell Sandell[2], Amit J. Jhala[2], Ryan S. Henry[1], Mayank Malik[3], Simone Seifert-Higgins[4], Tony D. White[4], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]Monsanto, Lincoln, NE, [4]Monsanto Company, St. Louis, MO (21)

Several glyphosate-resistant broadleaf weed species have been reported in Nebraska and neighboring states in the past several years. To conserve soil water in both rainfed and irrigated cropping systems many acres in Nebraska are no-till, and producers look to preemergence and postemergence herbicides to manage glyphosate-resistant and other tough to control broadleaf weeds. The objective of these studies were to investigate the utility of adding dicamba as an additional postemergence weed control tool to manage glyphosate-resistant weeds in Nebraska soybean production systems. Studies were conducted during the summer of 2013 at Fremont, Waverly, Clay Center and Brule. Preemergence and postemergence herbicide treatments alone and in combination were evaluated. Weed species evaluated consisted of glyphosate-resistant common waterhemp, glyphosate-resistant horseweed, velvetleaf, ivyleaf morningglory and glyphosate-resistant kochia. In general, the use of a residual preemergent herbicides in a PRE-POST program provided the greatest efficacy of the weed species present. Preemergent residual herbicides used were flumioxazin + chlorimuron, flumioxazin + pyroxasulfone and sulfentrazone + metribuzin. The inclusion of dicamba or lactofen in postemergence treatments at the Fremont location provided better control of glyphosate-resistant common waterhemp. The utilization of multiple modes of action (including residual, systemic and contact herbicides) at different times during the growing season provided the greatest efficacy. The use of dicamba as a postemergence treatment helped in the control of broadleaf weed escapes from the preemergent residual applications. For producers, awareness of the presence of resistant weeds and the tools available to control them is essential.

BAS 18322H FOR GLYPHOSATE RESISTANT WATERHEMP CONTROL IN DICAMBA-TOLERANT SOYBEAN. Stevan Z. Knezevic[1], Jon E. Scott[1], Leo D. Charvat*[2]; [1]University of Nebraska-Lincoln, Concord, NE, [2]BASF Corporation, Lincoln, NE (22)

Weed resistance to ALS, glyphosate, HPPD, and PPO-inhibiting herbicides continue to appear in corn and soybean production systems, therefore, alternative herbicide choices such as dicamba are of interest. While corn is tolerant to dicamba, the introduction of dicamba tolerant soybeans provides another option for weed control. Field studies were conducted in 2013 in Nebraska's soybean cropping system with dicamba applied POST following a variety of pre-emergence treatments, which included: dimethenamid-p, flumioxazin, imazethapyr +saflufenacil, pyroxasulfone, and saflufenacil. BAS 18322H applied post-emergence at 560 g ai/ha provided 95% control of glyphosate resistant waterhemp; an additional post-emergence herbicide will be needed to obtain 100% control. Tank mixes with soil-residuals (dimethenamid-p or acetochlor) did not improve post-emergence control, but provided a bit longer lasting control. Most pre-emergence herbicides provided 100% control of waterhemp (except flumioxazin) for 6-7 weeks. BAS 18322H helped control of glyphosate resistant waterhemp when the residual products did not provide complete control. These results indicate potential use of BAS18322H to control glyphosate resistant waterhemp; however a repeated use of dicamba alone or dicamba-glyphosate combination should be avoided to reduce chance for dicamba resistance. In fact, the whole technology of dicamba-tolerant soybean should be used in conjunction with additional modes of actions as part of the Best Management Practice and Stewardship Program.

A197: A TECHNICAL OVERVIEW. Stott Howard*[1], Gordon D. Vail[2], John P. Foresman[2]; [1]Syngenta Crop Protection, Des Moines, IA, [2]Syngenta Crop Protection, Greensboro, NC (23)

A197 is a multiple mode-of-action herbicide premix that provides preemergence and postemergence grass and broadleaf weed control in field corn, seed corn, popcorn and sweet corn. A197 will be the first Syngenta product that contains bicyclopyrone, a new HPPD (4-hydroxyphenyl-pyruvate dioxygenase) inhibitor, with anticipated first commercial applications in the 2015 growing season. A197 is effective on difficult-to-control weeds, including common lambsquarters (*Chenopodium album*), common ragweed (*Ambrosia artemisiifolia*), giant foxtail (*Setaria faberi*), giant ragweed (*Ambrosia trifida*), Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus rudis*) with improved residual control and consistency compared to commercial standards.

CONTROL OF GLYPHOSATE-RESISTANT VOLUNTEER CORN IN GLUFOSINATE-RESISTANT SOYBEANS. Parminder S. Chahal*[1], Greg R. Kruger[2], Lowell Sandell[1], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (24)

Glyphosate-resistant volunteer corn (*Zea mays*) is a problematic weed in soybeans grown in rotation. Information is available for control of glyphosate-resistant corn volunteers in glyphosate-resistant soybean, but not in glufosinate-resistant soybean. Field experiment was conducted in Clay County, NE to evaluate efficacy of glufosinate applied alone or in a tank mix with graminicides for control of glyphosate-resistant corn volunteers. Control of volunteer corn was variable until late-POST application of glufosinate; however, after that, application of glufosinate provided > 90% control to glyphosate-resistant volunteer corn reducing the volunteer corn density to 0. The result of this study indicates that glyphosate-resistant volunteer corn can be adequately controlled by glufosinate applied alone or in tank mix with graminicides.

TIMING OF VOLUNTEER CORN CONTROL AFFECTS SUGARBEET YIELD. Amanda C. Harden*, Christy L. Sprague; Michigan State University, East Lansing, MI (25)

Volunteer glyphosate-resistant corn is one of the most common weed problems found in glyphosate-resistant sugarbeet grown in Michigan. Field trials were conducted in 2012 and 2013 at the Michigan State University Agronomy Farm in East Lansing and at the Saginaw Valley Research and Extension Center near Richville, Michigan to examine the impact of volunteer glyphosate-resistant corn on glyphosate-resistant sugarbeet yield and sucrose quantity and quality. This research compared two herbicide options for volunteer corn control at five different application timings based on corn stage. Glyphosate-resistant sugarbeet 'HM 9173 RR' was planted at 124,000 plants ha$^{-1}$ in 76-cm rows. Directly after, '$F_2$' glyphosate-resistant 'DeKalb 46-61' corn seed was planted approximately 13-cm off the center sugarbeet rows at a target population of 17,220 plants $ha^{-1}$ (1.7 plants $m^{-2}$). Plots were kept weed-free throughout the season with glyphosate at 0.84 kg a.e. $ha^{-1}$. The two herbicide programs examined were: 1) clethodim (105 g $ha^{-1}$) + glyphosate (0.84 kg a.e. $ha^{-1}$) + ammonium sulfate (2% w/w) and 2) quizalofop (34 g $ha^{-1}$) + glyphosate (0.84 kg a.e. $ha^{-1}$) + non-ionic surfactant (0.125% v/v) + ammonium sulfate (2% w/w). These treatments were applied at five different stages when volunteer corn was between the V2 and V11 growth stage. Clethodim and quizalofop rates were increased as corn size increased. Volunteer corn control was evaluated throughout the season and the remaining volunteer corn biomass was harvested and weighed prior to sugarbeet harvest. Sugarbeet were harvested for yield and sucrose quantity and quality. Clethodim and quizalofop were equally effective at controlling volunteer glyphosate-resistant corn. In 2012, volunteer corn did not reduce sugarbeet yield or quality at Richville. This was attributed to extremely low early season precipitation which delayed corn growth. In 2013, sugarbeet yield was reduced when corn was not controlled until the V8 stage. Yield was reduced 12% and 34% when corn was controlled at the V8 and V11 stages, respectively. At East Lansing in 2012, uncontrolled corn reduced recoverable white sugar by 31% and yield by 35%. In 2013, corn controlled at the V2, V6, V8, and V10 stage yielded higher than uncontrolled corn. Variability occurred due to poor corn germination and a consequential replanting of volunteer corn at the 2-leaf stage of sugarbeet. Although there was variability within the years, volunteer glyphosate-resistant corn should be controlled with clethodim or quizalofop prior to the V8 corn stage to maximize sugarbeet yield and quality.

DRY BEAN DESICCATION WITH VARIOUS HERBICIDES IN CANADA. Nader Soltani*[1], Robert E. Blackshaw[2], Rob Gulden[3], Chris Gillard[1], Christy Shropshire[1], Peter H. Sikkema[1]; [1]University of Guelph-Ridgetown, Ridgetown, ON, [2]Agriculture Canada, Alberta, AB, [3]University of Manitoba, Manitoba, MB (26)

There is little information available on the effect of diquat, carfentrazone-ethyl, glufosinate ammonium, flumioxazin and saflufenacil applied alone or in tankmix combination with glyphosate as harvest aids in dry bean production under environmental conditions of the various production regions in Canada. A total of eleven field trials were conducted over a three-year period (2010, 2011, 2012) at Exeter, Ontario; Carman, Manitoba and Lethbridge, Alberta to evaluate various harvest-aid herbicides in dry bean. Comparison of leaf, pod and stem visual dry down at 4 and 8 days after desiccation application (DAA) indicated that adding a tankmix partner to glyphosate increased visual dry down of leaf, pod and stem 17, 10 and 15% at 4 DAA and 20, 17 and 14% at 8 DAA, respectively. At 8 DAA, glyphosate (450 or 900 g ae $ha^{-1}$), diquat, glufosinate ammonium, carfentrazone-ethyl, flumioxazin and saflufenacil provided 13-58, 65-80, 64-71, 12-34, 36-52 and 41-73% dry down of the dominant weeds (AMARE, AMBEL, CHEAL and SETVI), respectively. Diquat, glufosinate ammonium, carfentrazone-ethyl, flumioxazin and saflufenacil tankmixed with glyphosate (450 or 900 g ae $ha^{-1}$) provided 67-77, 65-71, 22-62, 45-69 and 44-74% weed dry down, respectively. Dry bean yield was not reduced with any of the desiccation treatments. Among desiccant treatments that provided consistent desiccation of dry bean and weeds, saflufenacil had the least environmental impact followed by flumioxazin, glufosinate ammonium and then diquat. Based on this study, diquat, glufosinate ammonium, flumioxazin and saflufenacil alone or in combination with glyphosate (450 or 900 g ae $ha^{-1}$) provide consistent desiccation of weeds and dry bean.

THE EFFECT OF ADJUVANTS AND NOZZLES ON CLORANSULAM, GLYPHOSATE, AND DICAMBA EFFICACY AND DROPLET SIZE. Fernanda S. Antonio*, Ryan S. Henry, Andre O. Rodrigues, Jesaelen G. Moraes, Rafael Werle, Cody F. Creech, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (27)

Previous research has demonstrated that herbicide efficacy can be impacted by spray droplet size. In the near future, EPA regulations will encourage agriculturalists to reduce drift by employing through drift reduction technology (DRT). Therefore, a greenhouse experiment was conducted in North Platte, NE to evaluate the impact of DRT on herbicide efficacy. Treatments included three herbicides, cloransulam-methyl (0.18 g ai/ha), glyphosate (1260 g ae/ha), and dicamba (560 g ae/ha) alone, and in combination with four DRT adjuvants. In addition, six nozzles (XR 11003, AIXR 11003, TT I11003, ULD 120-03, TT 11003 and TTJ 11003) were used in this study. Applications were made with a single nozzle track sprayer at 94 L/ha. The treatments were applied to two plant species: soybean (*Glycine max*), tomato (*Solanum lycopersicum*). Visual estimations of injury were collected at 7, 14, and 28 days after treatment (DAT) using a scale of 0 – 100 where 0 = no injury and 100 = plant death. Plant wet weights were taken at 28 DAT and dry weights at 35 DAT. The treatments did not affect the herbicide efficacy on soybean, although differences were observed for tomato. This data indicates the need to further explore this topic, as it has implications for herbicide resistance management.

## THE IMPACT OF DROPLET SIZE ON THE EFFICACY OF 2,4-D, ATRAZINE, CHLORIMURON, DICAMBA, GLUFOSINATE, AND SAFLUFENACIL. Jesaelen G. Moraes*, Rafael Werle, Fernanda S. Antonio, Andre O. Rodrigues, Cody F. Creech, Ryan S. Henry, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (28)

Herbicides are heavily relied upon as the primary source for weed control in many agricultural systems. However, herbicide applications are often ineffective as only a small amount of the active ingredients reach the intended target. Consequently, environmental contamination and/or loss of profitability may occur in this circumstance. Applicators must choose how to make the herbicide application based on the recommendations of pesticide labels and the equipment they operate. Selecting the appropriate application parameters and equipment can allow applicators to maximize their applications. The objective of this experiment was to evaluate the effect of droplet size on the efficacy of six commonly used herbicides applied to different plant species that are either considered weeds or represent different weeds in plant architecture or morphology. Atrazine (1.12 kg ai/ha), cloransulam-methyl (0.18 g ai/ha), dicamba (0.14 kg ae/ha), glufosinate (0.59 kg ai/ha), saflufenacil (12.48 g ai/ha), and 2,4-D (0.20 kg ae/ha) were applied using an XR11003 nozzle at 138, 276, and 414 kPa and a AI11003 nozzle at 207, 345, and 483 kPa. Each herbicide and nozzle/pressure combination was evaluated for droplet spectra at the Pesticide Application Technology (PAT) Lab, West Central Research and Extension Center, University of Nebraska-Lincoln in North Platte, NE. Applications were made using a single nozzle track sprayer which used different speeds to ensure each treatment was applied at 131 L/ha. The treatments were applied to seven plant species: soybean (*Glycine max*), tomato (*Solanum lycopersicum*), shattercane (*Sorghum bicolor*), corn (*Zea mays*), velvetleaf (*Abutilon theophrasti*), sunflower (*Helianthus annuus*), and common lambsquarters (*Chenopodium album*). Visual estimations of injury were collected at 7, 14, and 28 days after treatment (DAT) using a scale of 0 – 100 where 0 = no injury and 100 = plant death. At 28 DAT, plants were clipped at the soil surface and wet weights were recorded. These samples were then dried and dry weights were recorded. Results varied depending on the herbicide and the plant species. It is evident from the results that certain herbicides perform best within a droplet spectra range. These results demonstrate the importance of selecting an appropriate nozzle and pressure to mitigate potential drift while maintaining the efficacy of the herbicide application.

## GLYPHOSATE, FLUAZIFOP, LACTOFEN, AND DICAMBA EFFICACY AS IMPACTED BY ADJUVANTS AND NOZZLES. Andre O. Rodrigues*, Fernanda S. Antonio, Jesaelen G. Moraes, Rafael Werle, Cody F. Creech, Ryan S. Henry, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (29)

Adjuvants are known to alter spray quality and efficacy of herbicide applications. The objective of this study was to evaluate the impact of different types of adjuvants when added to four herbicides and applied through three commonly used nozzles. The treatments consisted of four herbicides, glyphosate (0.79 kg ae/ha), fluazifop (0.07 kg ai/ha), lactofen (0.11 kg ai/ha) and dicamba (0.14 kg ae/ha), alone and in combination with a non-ionic surfactant (NIS) (0.25% v/v), crop oil concentrate (COC) (1% v/v), methylated seed oil (MSO) (1% v/v), high surfactant oil concentrate (HSOC) (1% v/v), ammonium sulfate (AMS) (17 lb ai/100 gal), and a drift reducer (DRT) (0.29 l/ha). These chemical combinations were then sprayed with XR, AIXR and TTI nozzles to achieve different droplet spectrums. Glyphosate, fluazifop and dicamba treatments were applied at 94 L/ha with a 110015 tip, and lactofen was applied at 187 L/ha with a 11003 tip. All herbicide, adjuvant, and nozzle combinations were applied to five plant species, corn (*Zea mays*), shattercane (*Sorghum bicolor*), flax (*Linum usitatissimum*), velvetleaf *(Abutilon theophrasti*) and grain amaranth (*Amaranthus hypochondriacus*). Fluazifop treatments were only applied to grass species. Plants were grown inside a greenhouse located at the Pesticide Application Technology (PAT) Lab, West Central Research and Extension Center, University of Nebraska-Lincoln in North Platte, NE. Applications were made using a single nozzle track sprayer at the same location. Visual estimations of injury were collected at 7, 14, and 28 days after treatment (DAT) using a scale of 0 – 100 where 0 = no injury and 100 = plant death. At 28 DAT, plants were clipped at the soil surface and wet weights were recorded. These samples were then dried and dry weights were recorded. Generally, the addition of adjuvants increased the efficacy of the four herbicides tested. Some adjuvants had a greater impact than others and were often species specific. The addition of adjuvants to enhance herbicide applications is highly recommended but further testing is needed to understand which situations are best suited for different application conditions and intended targets.

HERBICIDE EFFICACY AS INFLUENCED BY CARRIER VOLUME AND WEED SIZE. Cody F. Creech*[1], Rafael Werle[1], Jesaelen G. Moraes[1], Andre O. Rodrigues[1], Fernanda S. Antonio[1], Ryan S. Henry[1], Lowell Sandell[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (30)

Understanding the effects of spray application factors on herbicide performance may contribute to increased efficacy. With the presence of glyphosate-resistant weeds in agricultural fields, maximizing herbicide efficacy to control these difficult weeds is paramount. Proper selection of carrier volume and understanding how carrier volume affects droplet size may help to improve herbicide efficacy. The objective of this greenhouse study was to measure the influence of carrier volume on herbicide performance and droplet spectra. The effects of six carrier volumes (47, 70, 94, 140, 187, and 280 L/ha) were evaluated with five herbicides. Glyphosate (0.87 kg ae/ha), glufosinate (0.59 kg ai/ha), lactofen (0.11 kg ai/ha), 2,4-D (0.20 kg ae/ha), and fluazifop (0.07 kg ai/ha) were applied at half the recommended labeled rates with each carrier volume. In addition, any adjuvants that were recommended on the labels were added at full rates. Each herbicide and carrier volume combination was evaluated for droplet spectra at the Pesticide Application Technology (PAT) Lab, West Central Research and Extension Center, University of Nebraska-Lincoln in North Platte, NE. These same combinations were applied to five plant species, corn (*Zea mays*), shattercane (*Sorghum bicolor*), flax (*Linum usitatissimum*), velvetleaf (*Abutilon theophrasti*) and grain amaranth (*Amaranthus hypochondriacus*). Fluazifop treatments were only applied to grass species and 2,4-D was only applied to broadleaf species. Treatments were applied when plants were at two growth stages: approximately 10 and 32 cm. Applications were made using a single nozzle track sprayer at the PAT Lab. Visual estimations of injury were collected at 7, 14, and 28 days after treatment (DAT) using a scale of 0 – 100 where 0 = no injury and 100 = plant death. At 28 DAT, plants were clipped at the soil surface and wet weights were recorded. These samples were then dried and dry weights were recorded. Generally, herbicide performance increased as carrier volume increased. The contact herbicides glufosinate and lactofen responded more to the increase in carrier volume. Using carrier volumes on the higher end of the recommendations on the labels will provide the best control.

EFFICACY OF DICAMBA & GLYPHOSATE APPLIED THROUGH COMMERCIAL APPLICATION EQUIPMENT. Stephen A. Valenti*[1], Joseph J. Sandbrink[2], Jeff N. Travers[2]; [1]Monsanto, Fargo, ND, [2]Monsanto Company, St. Louis, MO (31)

In 2012, field trials were conducted at 13 locations across the United States to investigate the efficacy of glyphosate+dicamba premix applications when applied through very coarse to ultra coarse nozzles on tough to control weeds including, common ragweed (*Ambrosia artemisiifolia L.*), kochia (*Kochia scoparia (L.*), Palmer amaranth (*Amaranthus palmeri S. Wats*), and glyphosate-resistant (GR) waterhemp (*Amaranthus rudis Sauer*). The results from 2012 indicated at least 96 percent weed control across all weed species for the final evaluation for TurboTeeJet® Wide Angle Flat Spray Tip (TT), Turbo TeeJet® Induction Flat Spray Tip (TTI), and TeeJet® Air Induction XR Flat Spray Tip (AIXR). This experiment was repeated again in 2013 across 13 locations. The nozzles selected include the following spray tips: AIXR TeeJet® Air Induction XR Flat Spray Tip (AIXR), the Turbo TeeJet® Induction Flat Spray Tip (TTI), Greenleaf Airmix® Low Pressure (AM), and the Hypro®Ultra Lo-Drift ™ (ULD). All spray solutions contained glyphosate (1120 g ae/ha), dicamba (560 g ae/ha), drift reduction additive (DRA) (290 g ai/ha), and MON 10 at 4 %v/v. Applications were made with commercial application equipment with spray booms ranging in size from 12.1 to 30.48 m. Sprayer travel speed ranged from 8.04-20.92 km/h, while operating pressure ranged from 206.84-344.73 kPa. The application volume was 93.69-140.53 L/Ha. Treatments were applied postemergence (POST) to corn or to fallow fields, weed heights ranged from 5.1-76.2 cm depending on the species. Average weed control ratings for the final evaluation, across all species, locations, and rating dates were 97.7, 97.8, 97.9, and 97.3% for the AIXR, TTI, Airmix, and ULD nozzles respectively. There were no significant differences across the four nozzles within individual weed species, which included common lambsquarters (*Chenopodium album L)*, common ragweed (*Ambrosia artemisiifolia L.*), henbit (*Lamium amplexicaule L.*), horseweed (*Conyza canadensis (L.) Cronq.*), ivyleaf mornigglory (*Ipomoea hederacea Jacq),* kochia (*Kochia scoparia (L.) Schrad*), Palmer amaranth (*Amaranthus palmeri S. Wats*), Russian thistle (*Salsola kali*), tall waterhemp (*Amaranthus rudis Sauer*). These results suggest that dicamba plus glyphosate mixtures will provide very good weed control when sprayed through recommended drift reducing nozzles at the rates recommended by Monsanto, while decreasing off target movement of this herbicide combination.

PROPOSED LABEL APPLICATION REQUIREMENTS FOR DICAMBA IN ROUNDUP READY® XTEND CROP SYSTEMS. Susan E. Curvey*, Jeff N. Travers, Joseph J. Sandbrink, Thomas B. Orr, Helen E. Mero; Monsanto Company, St. Louis, MO (32)

Monsanto is preparing to introduce two new herbicide products containing low volatility dicamba formulations for use in dicamba-tolerant soybeans and cotton. When the new herbicides are registered in the two crops, there will be a glyphosate plus dicamba premix and dicamba straight good used for tank-mixing. Both herbicides will include Vapor Grip™ technology, a low volatility innovation from Monsanto. The stewardship platform from Monsanto will implement label mandated Application Requirements to drive proper on target application. Pre-emergent and Post-emergent dicamba applications will have defined application guidelines. Requirements will address nozzle types, droplet size, wind speed, boom height, weed size, ground speed, buffer distance to sensitive crops, and tank cleanout procedures. ALWAYS READ AND FOLLOW PESTICIDE LABEL DIRECTIONS. Roundup Ready® and VaporGrip™ are trademarks of Monsanto Technology LLC. All other trademarks are the property of their respective owners. ©2013 Monsanto Company.

EFFECT OF CARRIER VOLUME ON GROWTH REGULATOR AND CONTACT HERBICIDE TANK-MIXTURES. Strahinja Stepanovic*[1], Matheus Palhano[1], Greg R. Kruger[2], Lowell Sandell[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (33)

Control of glyphosate resistant populations of common waterhemp (*Amaranthus rudis*) has been an increasing problem in soybean production throughout the Midwestern US. Although glufosinate-tolerant and impending dicamba-tolerant and 2,4-D-tolerant crops will enable these herbicides to provide equivalent efficacy in managing glyphosate-resistant common waterhemp populations, to prevent the evolution of multiple resistance and keep other herbicide options viable, tank mixtures of different systemic and contact herbicides need to be evaluated. A greenhouse experiment was conducted in 2013 at University of Nebraska-Lincoln's east campus greenhouses to evaluate control of glyphosate-resistant common waterhemp with postemergence (POST) applications of 2,4-D, dicamba, glufosinate, lactofen, and tank mixtures of glufosinate or lactofen with 2,4-D or dicamba at 94 and 188 L $ha^{-1}$ spraying volume. Common waterhemp was grown in 35.5 cm by 50.8 cm flats at densities equivalent to 100 plants per square meter (18 plants per flat) with equidistant plant spacing within the flats. Herbicide treatments were applied in a single nozzle spray chamber when plants were 10 cm tall. Visual estimations of injury and percent mortality ratings were collected at 7, 14, 21 and 28 days after treatment (DAT), and weed dry matter was recorded at 28 DAT. Results show that efficacy of herbicide treatments was not changed with spraying volume, except for Dicamba that had lower weed control and mortality rates with 188 L $ha^{-1}$ applications than at the 94 L $ha^{-1}$ applications. When applied individually, 2,4-D and dicamba provided 83 to 90% control, whereas glufosinate and lactofen had >95% control of common waterhemp at 28 DAT. When glufosinate was combined with 2,4-D or dicamba high efficacy (>95%) was maintained, while tank mixtures of lactofen plus either 2,4-D or dicamba were the most effective herbicide treatments resulting with weed control levels >99%, mortality rates >90% and dry matter <6 $g/m^2$. Tank mixtures of glufosinate or lactofen with growth regulator herbicides has a potential to effectively control glyphosate-resistant common waterhemp and delay further evolution of herbicide-resistant common waterhemp populations.

EFFECT OF WATER TEMPERATURE AND STORAGE DURATION ON MON 76757. Pratap Devkota*, William G. Johnson; Purdue University, West Lafayette, IN (34)

Water is the primary herbicide carrier solution; therefore, water related factors can greatly influence herbicide performance. Limited studies have been published to address the influence of herbicide carrier water temperature and solution storage duration on herbicide efficacy. A greenhouse study was conducted to evaluate the effect of carrier water temperature and herbicide solution storage duration on the weed control efficacy of MON 76757 (a formulated premix of glyphosate and dicamba). Treatments consisted of carrier water temperature at 5, 22, 39, and 56 C; and herbicide solution storage duration at 0, 6, and 24 hours after mixing herbicide. MON 76757 was evaluated at 0.58 (glyphosate at 0.277 plus dicamba at 0.137 kg ae/ha) and 1.16 L/ha (0.55 kg ae/ha plus dicamba at 0.275 kg ae/ha) for giant ragweed, horseweed, pitted morningglory, and velvetleaf control. Data was collected for weed control at weekly interval for 3 wk, and after the final rating shoot biomass was harvested and oven dried shoot weight was recorded. The spray water temperature and solution storage duration did not have interaction effect on the weed control efficacy of MON 76757. Similarly, solution storage duration up to 24 hours did not affect the efficacy of MON 76757. Herbicide carrier water temperatures did affect Mon 76757 efficacy. The effect was dependent upon the weed species. There was no effect of carrier water temperature on horseweed, pitted morningglory, and velvetleaf control. Giant ragweed control differed with differences in carrier water temperature. At 3 WAT, giant ragweed control was 57 and 65% at 5 and 39 C, respectively, with MON 76757 at 0.58 L/ha. Similarly, giant ragweed control was 63 and 72% at 5 and 39 C, respectively, with MON 76757 at 1.18 L/ha. Therefore, lower carrier water temperature reduced giant ragweed control with MON 76757.

AN EVALUATION OF THREE DRIFT REDUCTION TECHNOLOGIES FOR AERIAL APPLICATION OF PESTICIDES. Ryan S. Henry*[1], Annah Geyer[1], William E. Bagley[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Wilbur-Ellis, San Antonio, TX (35)

Aerial application of pesticides is a common practice in the US. This method has several advantages over ground applications, including timeliness of applications and lack of mechanical damage to the crop from the sprayer. Given the inherent nature of aerial appliations, it is critical to ensure the operational setup delivers maximum performance with minimal drift, and this requirement increases with the speed of the application. It is now common for aerial applicators to travel at speeds up to 160 mph. In light of the rising commodity and crop prices and the pending EPA regulations regarding drift mitigation, datasets examining the effect of drift reduction adjuvants (DRAs), nozzle type, and application speed will benefit aerial applicators and the public at large. A combination of two herbicides and three DRAs were tested at several airspeeds using three nozzles in a high speed wind tunnel. As airspeeds increased, droplet size decreased across all treatment combinations. The inclusion of a DRA had little to no effect on droplet size, especially at higher airspeeds.

DRIFT REDUCTION TO SOYBEAN FIELDS WHEN USING BEST MANAGEMENT PRACTICES WITH ENLIST DUO. David M. Simpson*, Fikru Haile, Jerome J. Schleier; Dow AgroSciences, Indianapolis, IN (36)

Enlist Duo™ herbicide with Colex-D™ Technology is a proprietary blend of 2,4-D choline and glyphosate for use on Enlist™ crops. Colex-D Technology reduces the volatility of 2,4-D and minimizes the potential for drift of Enlist Duo herbicide. When Enlist Duo with Colex-D Technology is used in combination with drift reduction nozzles, previous studies with University of Nebraska have shown a 90% reduction in spray drift compared to 2,4-D amine + glyphosate tank mix sprayed with a XR nozzle. Six large scale drift trials were established in IN (2), IL, KS, MN and MS to determine the amount of spray drift and subsequent crop injury in non-Enlist soybean fields adjacent to fields treated with Enlist Duo™ herbicide using the recommended nozzle, spray pressure, boom height and wind speed. Enlist Duo at 2185 g ae/ha was applied with commercial scale sprayers calibrated to deliver 15 gallons/A with nozzles and pressure that produced very coarse to extremely coarse spray droplets and boom height of 24 inches. Wind speeds ranged from 3 to 12 mph across locations Rhodamine dye was added at 0.02% v/v to the spray volume to determine amount of deposition downwind. Petri dishes were placed at 12.5, 25, 50, 100, 125, 150, 200, 225 and 250 ft from the downwind edge of the sprayed area in 3 transects located at the middle of sprayed distance and on 50 ft on either side of the middle. Petri dishes were collected immediately after application and shipped to the lab where they were rinsed and amount of dye captured was quantified by fluorometry. Visual crop tolerance ratings were taken at 7, 14 and 28 days after application at each sampling point. Maximum injury occurred 28 days after application at 12.5 ft with average injury of 11%. At 25 ft, only slight injury (1%) was reported and no injury reported beyond 25 ft. The average amount of Enlist Duo at 12.5, 25, 50, 100, 150, 200 and 250 ft were 33, 7, 4, 1.7, 1, 0.8, 0.7 g ae/ha, respectively. These trials demonstrate that Enlist Duo, when applied with correct nozzle, pressure, boom height and wind speed, can be applied within 25 ft of an adjacent to a soybean field that does not contain the Enlist trait without causing significant crop injury.

™Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow. Regulatory approvals are pending for the Enlist herbicide solution and crops containing Enlist herbicide tolerance traits. The information presented here is not an offer for sale. Always read and follow label directions. ©2013 Dow AgroSciences LLC

USE OF NON-TRADITIONAL EXTENSION OUTREACH TOOLS FOR TURFGRASS WEED SCIENCE. Jared A. Hoyle*; Kansas State University, Manhattan, KS (37)

With technological developments in smartphones, tablets and applications, extension personnel are able to record, store, and analyze data efficiently. New non-traditional tools are able to collect information through normal extension operating procedures relating to turfgrass weed science. These tools include an automated field operation application, doForms™. doForms™ is a free application that allows users to build and customize electronic forms that can be used to record detailed information. The objective of this study is to survey the non-traditional outreach tool, doForms™, for efficiency, effectiveness, and application to extension in turfgrass weed science. doForms™ was downloaded, installed and forms were created for use during May 2013. For duration of the survey period, extension personnel testing doForms™ spent approximately 70% of extension related activities conducting on site visits with turfgrass managers. From conception to deployment of doForms™ approximately 3 hours was required. Information that was able to be collected by initial form included, date and time of contact between extension personnel and turfgrass manager, category of turfgrass manager (golf course superintendent, sod producer, athletic field manager, residential/commercial landscape operator, etc.), nature of contact (telephone, email, text, social media, etc.), nature of response, subject matter (weeds, diseases, cultural practices, undetermined, etc.), specific weed species, and location. Information that was obtained from initial testing included time allocated to data acquisition, effort to extract data, and practicality. Extension personnel discovered that minimal effort was required to operate doForms™. After the conclusion of extension site visit data could be recorded in less than one minute. Ability to extract data from computer interface required negligible effort. Extension personnel also noted that the ability for the user to record data on devices that were already in their position increased practicality. Although, doForms™ greatly increased extension personnel in efficiency and effectiveness of data collection disadvantages were also observed. Extension personnel were not able to alter forms previously created and must create new forms if desired. The inability to alter forms negatively impacts data extraction. Ultimately, the use of applications such as doForms™ can allow extension personnel to obtain information efficiently and effectively. Due to the minimal time required to record data with applications such as doForms™, extension personnel are able to devote additional time to other activities, ultimately increasing efficiency. Most importantly this allows issues in turfgrass weed science from extension outreach practices to become location and time stamped for the development of focused extension programs and current research projects.

MANUAL FOR PROPANE-FUELED FLAME WEEDING IN CORN, SOYBEAN, AND SUNFLOWER. Stevan Z. Knezevic*[1], Avishek Datta[2], Chris Bruening[3], George Gogos[3], Jon E. Scott[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska-Lincoln, Lincoln, NE (38)

Flame weeding is an approved method for weed control in organic cropping systems, with the potential for use in conventional agriculture. From 2006-2012 we have conducted a series of over 40 studies, which were funded by PERC and other sources (eg. USDA). This extensive work resulted in over 20 journal and proceeding articles about crop tolerance to heat and weed control with flame weeding in field corn, popcorn, sweet corn, sunflower, soybean, sorghum and winter wheat. We compiled the above research information into a training manual that describes the proper use of propane fueled flaming as a weed control tool in six agronomic crops (field corn, popcorn, sweet corn, soybean, sorghum, and sunflower). The flame weeding manual contains 32 pages of text and color pictures. The pictures provide visuals of crop growth stages when flaming can be conducted safely without having side-effects on crop yield. Pictures of weeds provide visuals of appropriate growth stages when weeds need to be flamed to achieve good weed control. There are six chapters in the manual: (1) The need for alternative weed control methods; (2) Propane fueled-flame weeding; (3) How flame weeding works; (4) Equipment and configurations; (5) Propane dosage at different weed growth stages, and (6) Crop Tolerance to post-emergent flame weeding. We believe that our manual provides a recipe on how to use flaming procedures and it is written in a user friendly manner that can be understood by the general public. The manual is free, it can be downloaded in a pdf format from the following website: http://www.agpropane.com/propane-safety-on-the-farm/service-manuals-and-training-guides/

TIME OF WEED REMOVAL IN CORN AND SOYBEANS, A FIELD TEACHING TOOL - SEEING IS BELIEVING. Lisa M. Behnken*[1], Fritz Breitenbach[1], Jeffrey L. Gunsolus[2], Ryan P. Miller[1]; [1]University of Minnesota, Rochester, MN, [2]University of Minnesota, Saint Paul, MN (39)

Proper time of weed removal in corn and soybean is a critical component of successful weed control programs that maximize crop yields.  Field demomstrations and hands-on schools can be an effective way of teaching agricultural professionals and farmers the importance of this concept - seeing is believing.  Over-reliance on postemergence glyphosate programs in both corn and soybean has resulted in a reduction of herbicide diversification, a dramatic drop in the use of preemergence herbicides, and over simplified weed management programs.  The end results, increased early season weed competition,  decreased time to effectively control weed populations, increased weed densities to be controlled by postemergence programs, increased risk of developing resistant weed populations, and ultimately reduced crop yield potential.  Field demonstrations showing different times of weed removal and preemergence followed by postemergence herbicide systems in corn and soybean were established in 2012 and 2013 at Rochester, Minnesota.  Weeds were removed with herbicides at the following crop stages in corn and soybean: at planting, V2-V3, V4-V5 and V6-V7.  In addition, programs comparing broad and limited spectrum preemergence herbicides (based on control of weed species present at site) followed by both timely and untimely postemergence herbicide programs were established.  Agricultural professionals attending the field schools were shown the impact time of weed removal has on weed/crop competition, herbicide performance or lack of, and the reduced windows of opportunities to control weeds.  In addition, attendees were asked to choose the best systems and rank the treatments based on performance - which would they recommend to their growers.  Participants responded very favorably to this method of demonstrating and teaching the concepts and importance of proper time of weed removal and diversified weed management programs.  They also recommended additional field demonstrations and schools featuring new products and technologies as available.

PLANNING AND CONDUCTING FIELD DEMONSTRATION TOURS. Bruce E. Maddy*[1], David E. Hillger[2], Gary A. Finn[2], Jeff M. Ellis[3], Eric F. Scherder[4], David C. Ruen[5], Corey K. Gerber[6], Fritz Koppatschek[7], Luke A. Peters[2]; [1]Dow AgroSciences, Noblesville, IN, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Smithville, MO, [4]Dow AgroSciences, Huxley, IA, [5]Dow AgroSciences, Lanesboro, MN, [6]Purdue University, West Lafayette, IN, [7]ABG Ag Services, Sheridan, IN (40)

*NO ABSTRACT SUBMITTED*

GLOBAL TECHNOLOGY TRANSFER AT DOW AGROSCIENCES: BLENDED LEARNING FOR EMPLOYEE AND CUSTOMER EDUCATION. Gary A. Finn[1], Bruce E. Maddy[2], Ed King[1], David E. Hillger*[1]; [1]Dow AgroSciences, Indianapolis, IN, [2]Dow AgroSciences, Noblesville, IN (41)

What is Global Technology Transfer (GTT)? GTT is the “bridge between R&D & commercial”.  The goal of GTT is to deliver product and agronomic instructional tools to train customer-facing employees and support product launches. GTT provides “one-stop shopping” of approved training and reference materials that are understandable for commercial positioning and customer education and create learning tools and environments that provide employees the knowledge and resources to represent and sell the value of our products with confidence.  GTT provides blended learning approaches based on adult education “best practices” including Instructor-led live training, multiple e-learning tools, phased “learning bytes” to master complex topics, and reference materials.

TAKE ACTION: A COOPERATIVE HERBICIDE RESISTANCE EDUCATIONAL PROGRAM. William G. Johnson, Travis Legleiter*; Purdue University, West Lafayette, IN (42)

A collaborative effort to increase and unify the herbicide-resistance educational programing has been developed by 16 Universities through the funding of the United Soybean Board.  The effort is being housed under a branded message of “Take Action” with four underlying themes: “Weed Out Resistance”, “In The Field”, “Spray Attention”, and “The Bottom Line”.  The message emphasizes the importance of weed identification and biology; incorporation of cultural practices; the knowledge and use of multiple sites of action; and understanding the risk and cost of herbicide resistance and weed management.  Current extension and branding efforts include the production of a “Weeds to Watch” poster, expansion of the “Herbicide Classification” chart, and development of one-page fact sheets for each weed identified on the “Weeds to

Watch" poster. A "Take Action" website is currently being designed as central point to access all developed materials as well as other educational weed resistance sources. All materials developed within the program will be used and distributed by participating Universities to educate producers, crop consultants, applicators, and the overall agronomic sector, about the importance of managing the development and spread of herbicide resistant weeds.

### PRO-ACTIVE LATE-SEASON WEED ESCAPE SURVEY IDENTIFIED GLYPHOSATE-RESISTANT HORSEWEED PRESENT AT LOW FREQUENCY IN WISCONSIN. Ross A. Recker*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (43)

Glyphosate-resistant weeds continue to be a major threat to corn and soybean production across the Nation, as glyphosate-resistant weeds have been confirmed in 32 states. In January 2012, a population of giant ragweed (*Ambrosia trifida* L.) from southern Wisconsin was announced as the first confirmed case of glyphosate resistance in the state. A pro-active survey of late-season weed escapes in corn and soybean fields was conducted throughout Wisconsin during late-July through early-September of 2012. One objective of this survey was to identify areas where additional biotypes of glyphosate-resistant weeds may exist. To find and identify locations for in-field sample locations, an on-line survey was distributed through newsletters and email list-serves to Wisconsin producers in June 2012 to generate contact information, field history information, and permission for in-field sampling. While conducting the in-field sampling, seed heads from 30-40 mature plants suspected to have escaped postemergence glyphosate applications were collected. Seed heads were collected as a composite sample and then threshed to attain clean seed for preliminary greenhouse screening experiments for glyphosate resistance in the spring of 2013. Glyphosate was applied to seven to ten putative susceptible and putative resistant plants at rates of 0, 0.43, and 0.87 kg ae ha$^{-1}$. All applications included ammonium sulfate at 0.02 kg L$^{-1}$ and were applied at 187 L ha$^{-1}$ total spray volume with water as the carrier. Full dose response experiments were conducted if warranted by the preliminary screens. There were 153 fields sampled in 2012 and preliminary screening for glyphosate resistance conducted for numerous populations of six different weed species. One population of horseweed (*Conyza canadensis* L.) from Jefferson County, WI was further subjected to a full glyphosate dose response experiment with six glyphosate rates of 0, 0.22, 0.43, 0.87, 1.74, and 3.48 kg ae ha$^{-1}$ following the initial screen. The effective dose of glyphosate needed to reduce dry horseweed biomass by 50% (ED$_{50}$) was estimated to be 1.59 kg ae ha$^{-1}$ and 0.28 kg ae ha$^{-1}$ for the Jefferson County putative resistant and putative susceptible population, respectively. Therefore, the plants from Jefferson County were confirmed glyphosate-resistant with nearly six-fold difference in response from the susceptible plants. The identification of this glyphosate-resistant horseweed population demonstrates the effective approach of the pro-active late-season weed escape survey. This approach was particularly successful because farmers do not usually recognize herbicide-resistant weed problems until the frequency of the resistance in a field is fairly high. However in this case, the accession of glyphosate-resistant horseweed occurred in two small patches of about 20 plants per patch. Furthermore, these were the only horseweed plants found throughout the entire late-season weed escape survey. With the early identification of this glyphosate-resistant horseweed population, hopefully future control of glyphosate-resistant horseweed through diversified weed management strategies can still be successful, and other farmers without glyphosate-resistant horseweed will adopt diversified management to augment the threat of this weed in Wisconsin.

### THE EFFECT OF GROWTH STAGE ON SWITCHGRASS ATRAZINE TOLERANCE. Whitney M. Churchman*, Michael Barrett, David W. Williams; University of Kentucky, Lexington, KY (44)

Switchgrass (*Panicum virgatum* L.) is a perennial grass used for soil conservation, livestock forage systems, wildlife habitat programs and, more recently, as a feedstock for biofuel production. Despite its many positive attributes, switchgrass can be very difficult to establish due to weed pressure. Atrazine can be used to control weeds in switchgrass but applications cannot be safely made until switchgrass is between 3 and 4 leaves. Unfortunately, this application timing can be too late to prevent weed competition. This study examines the effect of switchgrass seedling growth stage and herbicide rate on switchgrass sensitivity to atrazine. The objective of our experiment was to determine whether the field observations of switchgrass sensitivity to atrazine could be replicated in the greenhouse environment. 'Alamo' switchgrass plants were established in the greenhouse and were sprayed with atrazine (0.9 kg a.i. ha$^{-1}$ or 1.8 kg a.i. ha$^{-1}$) at the 1, 2, or 4 true leaf stage. All atrazine treatments contained crop oil concentrate at 1% v/v. Data collected two weeks after treatment included: Percent herbicide injury, and fresh weights and dry weights. These were compared to an untreated control. There was a significant atrazine rate by leaf stage interaction. Plants treated at the 1 true leaf were most sensitive to atrazine herbicide injury; while plants treated at the 4 true leaf stage were least sensitive. Across all leaf stages atrazine applications of 1.8 kg a.i. $ha^{-1}$ injured plants more than 0.9 kg a.i. $ha^{-1}$ of atrazine. These results are consistent with the field observations and support delaying atrazine application until switchgrass has at least 4 true leaves. Future studies will examine the rate of atrazine metabolism in switchgrass at these leaf stages.

## SELECTION BASED IMPROVEMET FOR 2,4-D TOLERANCE IN RED CLOVER . Tara L. Burke*, James Roberts, Norman Taylor, Michael Barrett; University of Kentucky, Lexington, KY (45)

Incorporation of a legume, such as red clover (*Trifolium pratense*), into grass pasture systems is advantageous for many reasons. However, susceptibility of red clover to herbicides commonly used in these systems limits its use; the Kentucky pasture weed management guide states that “In grass pastures interseeded with clover or other forage legumes, selective herbicide options are not available”. 2,4-D has long been a standard for pasture weed management, so a 2,4-D tolerant red clover would be very advantageous. Sufficient variability in red clover 2,4-D tolerance was identified suggesting that a 2,4-D tolerant red clover could be selected. A Florida red clover line with improved 2,4-D tolerance was crossed to 2,4-D susceptible Kenland and the resulting population was field selected for 2,4-D tolerance (2006-2012). To assess progress towards 2,4-D tolerance, plants were grown in the greenhouse from seed collected after the 2010 and 2011 selections and treated with 0.0, 0.5, 1.0, 1.5, or 2.0 kg/ha of 2,4-D. Plant fresh weights and injury at two weeks post-treatment were compared to similarly treated parent lines. The 2,4-D tolerance of the plants grown from the 2010 and 2011 seed, based on fresh weight reductions, was intermediate between the parent lines. Based on injury ratings, the 2010 and 2011 lines had 2,4-D tolerance similar to the Florida parent. Thus, while our cross to the 2,4-D tolerant Florida line increased 2,4-D tolerance compared to Kenland, little additional gain has been made in 2,4-D tolerance beyond that of the Florida line. This is despite numerous rounds of additional selection for 2,4-D tolerance. Future work will include studies to determine the potential role of metabolism in the increased 2,4-D tolerance as well as additional selection at higher rates of 2,4-D (2.24 kg/ha or higher).

## COMPARISON OF NEWER AND OLDER HERBICIDE OPTIONS FOR GUARDRAILS. Joe Omielan*, William Witt; University of Kentucky, Lexington, KY (46)

For highway safety guardrails need to be kept clear of visual obstructions. Usually that means maintaining a vegetation free zone underneath them. Applications of broad spectrum residual herbicides have become the mainstay for bareground maintenance operations in combination with a broad spectrum postemergent herbicide like glyphosate. A number of new products (Perspective, Viewpoint, Esplanade) have recently been introduced to this market. These trials evaluate the efficacy of these products and product combinations in comparison with older products. The trial was established under and beside guardrail near Paintsville, KY in 2012 and near Elizabethtown in 2013. In both years, 13 treatments and 3 replications were arranged in a randomized complete block design. Treatments were applied at 25 gallons/acre onto 6.5 ft by 12 ft plots on April 25, 2012 and May 23, 2013. All treatments included Roundup ProMax (glyphosate) for postemergence control. Treatments with older, high use rate herbicides included Sahara (diuron + imazapyr), Hyvar (bromacil), Pendulum (pendimethalin), and Endurance (prodiamine). Other herbicides used were Oust (sulfometuron), Payload (flumioxazin), Arsenal (imazapyr), and Journey (glyphosate + imazapic). Newer low use rate products tested included Milestone (aminopyralid), Perspective (aminocyclopyrachlor + chlorsulfuron), Viewpoint (aminocyclopyrachlor + metsulfuron + imazapyr), and Esplanade (indaziflam). Visual % bareground ratings were taken 40 (6/4), 85 (7/19), and 160 (10/2) days after treatment (DAT) in 2012 and 56 (7/18), 98 (8/29), and 138 (10/8) DAT in 2013. Data were analyzed using ARM software and treatment means were compared using Fisher’s LSD at p = 0.05. All treatments had more bareground than the control at the first assessment date in both years. In 2012 the Roundup ProMax treatment by itself was the same as the control 85 and 160 DAT. The most effective treatments included older, high use rate herbicides as well as low use rate herbicides by themselves. They were also effective as combinations with other low use rate herbicides or as combinations with high use rate ones. The introduction of new products has increased the available control options.

HERBICIDE COMBINATIONS FOR THE CONTROL OF NIMBLEWILL IN KENTUCKY BLUEGRASS LAWNS. Michael Barrett, Alexandra P. Williams*; University of Kentucky, Lexington, KY (47)

Nimblewill (*Muhlenbergia schreberi)* is persistent warm season perennial grass that can be difficult to control in cool season lawns. When actively growing, the grey-green colored nimblewill will form dense, obvious patches. When dormant, these patches transform into an unsightly straw-color. Topramezone is a new HPPD inhibiting herbicide labeled for the selective control of nimblewill in Kentucky bluegrass (*Poa pratensis*) lawns. Currently, mesotrione (also an HPPD inhibitor) is the standard herbicide used to selectively control nimblewill in Kentucky bluegrass. In the summer of 2013, a study was initiated at the A.J. Powell Jr. Turf Research Center in Lexington, KY to compare nimblewill control in Kentucky bluegrass using mesotrione, topramezone, and combinations of these herbicides with other common lawn herbicides. The eleven treatments that were used in this study were as follows: untreated control, mesotrione (0.175 kg/ha) applied twice 3 weeks apart; mesotrione (0.175 kg/ha) applied three times 3 weeks apart; topramezone (0.024 kg/ha) applied three times 3 weeks apart; topramezone (0.037kg/ha) applied twice 3 weeks apart; mesotrione (0.175 kg a.i./ha) + quinclorac (0.84 kg a.i./ha) applied twice 3 weeks apart; topramezone (0.037 kg/ha) + quinclorac (0.84 kg/ha) applied twice 3 weeks apart; mesotrione(0.175 kg/ha) + triclopyr (1.2 kg/ha) applied twice 3 weeks apart; topramezone (0.024kg/ha) + triclopyr (1.2 kg/ha) applied twice 3 weeks apart; topramezone (0.037kg/ha)+ triclopyr (1.2 kg/ha) applied twice 3 weeks apart; and fenoxaprop-p-ethyl (0.089 kg/ha) + triclopyr (1.2 kg/ha) applied four times every 4 weeks. Percent nimblewill control and percent Kentucky bluegrass injury were evaluated. All treatments, with the exception of the untreated control and the fenoxaprop-p-ethyl + triclopyr combination, significantly reduced the amount of nimblewill within the treated areas. Kentucky bluegrass was significantly injured by the mesotrione + quinclorac and topramezone + quinclorac treatments. We will continue to evaluate the efficacy of these products in 2014.

EFFECT OF HERBICIDE CARRYOVER IN COVER CROP CAPACITY TO AFFECT SOIL STRUCTURE AND NUTRIENT AVAILABILITY. Maria R. Rojas*, Darren Robinson, Laura Van Eerd, Ivan O'Halloran; University of Guelph-Ridgetown, Ridgetown, ON (48)

Cover crops improve soil aggregation and sequester nutrients to reduce leaching; many however, are not grown because they may be negatively impacted by herbicide residues applied in previous seasons. Our objective was to determine how nitrogen uptake by and soil aggregate stability under various spring and fall cover crops were influenced by previous application of three different herbicides. We hypothesized that herbicide residues will decrease cover crop nitrogen scavenging by roots and negatively influence cover crop ability to increase soil aggregate stability. Treatments were set in a randomized split plot factorial design. Herbicides treatments were saflufenacil/dimethenamid-p at 735 and 1470 g ha$^{-1}$, a tank mixture of s-metolachlor/benoxacor/ atrazine (2880 and 5760 g ha$^{-1}$) with mesotrione (140 and 280 g ha$^{-1}$), and imazethapyr (100 and 200 g ha$^{-1}$). Spring cover crops were spring wheat (*Triticum aestivum*), buckwheat (*Fagopyrum esculentum*), sorghum-sudangrass (*Sorghum bicolor spp. drummondii*) and annual rye (*Lolium multiflorum).* Fall cover crops in contrast were oilseed radish (*Raphanus sativus*), and fall oats (*Avena sativa*). Root organic nitrogen in labeled rates of saflufenacil was lower in annual rye compared to the untreated control. Annual rye root biomass in the mesotrione with s-metolachlor/ benoxacor was lower than the untreated control.

DOES CYPROSULFAMIDE SAFEN ISOXAFLUTOLE IN SWEET CORN? Darren Robinson*, Nader Soltani, Christy Shropshire, Peter H. Sikkema; University of Guelph-Ridgetown, Ridgetown, ON (49)

Four field trials were conducted during 2010 and 2011 in Ontario, Canada to compare the sensitivity of four sweet corn hybrids of varying levels of tolerance to HPPD-inhibiting herbicides to PRE and POST applications of isoxaflutole alone and in combination with cyprosulfamide. Isoxaflutole applied PRE or POST at 105 and 210 g ai ha$^{-1}$ caused as much as 12% visual injury, 18% reduction in height and 24% reduction in marketable yield of the most sensitive sweet corn hybrids evaluated. Isoxaflutole + cyprosulfamide applied PRE or POST at 105 and 210 g ha$^{-1}$ caused up to 7% initial injury in the more sensitive hybrids, but the injury was transient with no effect on sweet corn height, cob size, and yield. Isoxaflutole applied POST was more injurious to sweet corn than when applied PRE; however, there was no differences in sweet corn injury between the PRE and POST applications of isoxaflutole + cyprosulfamide. Based on these results, there is potential for use of isoxaflutole + cyprosulfamide applied at 105 g ai ha$^{-1}$ in Merit, GH 4927, BSS 5362, and GG 741 sweet corn hybrids. This study clearly demonstrates that cyprosulfamide safens isoxaflutole in sweet corn.

WEED MANAGEMENT OPTIONS DURING WINE GRAPE ESTABLISHMENT. Collin Auwarter*, Harlene M. Hatterman-Valenti, John E. Stenger; North Dakota State University, Fargo, ND (50)

A study to determine the effects of six different vineyard within row weed control options (landscape fabric, black plastic, straw, herbicide (Rely® glufosinate-ammonium and Chateau® flumioxazin), tillage, and turf) and four regional white wine cultivars (LaCrescent, Alpenglow, Brianna, and Frontenac Gris) was established at a research farm near Absaraka, ND in 2012. In 2012, the study vineyard was planted using 10 feet between rows and 8 feet between plants within rows in a randomized complete block design with treatments in a factorial arrangement having four replications. Plants were trained into a vertical shoot positioning trellis system. Both effects on weed populations as well as effects on grapevine growth were monitored. During 2012, vines were established and given watering as needed. In September of 2012, significant differences were found between weed control treatments in their abilities to control common lambsquarters (*Chenopodium album L.),* redroot pigweed *(Amaranthus retroflexus L.),* and common purslane (*Portulaca oleracea L.).* In the control of each weed species landscape fabric (99.7%, 100%, and 98.9%), black plastic (99.4%, 100%, and 98.4%), straw (98.8%, 98.75%, and 99.9%), and herbicide (92.8%, 100%, and 97.1%) had the best control. The least control was given by turf (87.2%, 94.3%, and 75.5%) and tillage (87.2%, 96.2%, and 74.0%). In the spring of 2013, measurements of growth during 2012 were taken. Pruning weights (g) and trunk base diameter (mm) differed between vines treated with different weed control treatments. In both measurements, vines having black plastic (30.89g, 12.1mm) and landscape fabric (24.8g, 11.1mm) had the greatest growth in 2012. Vines receiving sod (7.8g, 9.4mm), tillage (6.3g, 10.1mm), and straw (7.0g, 10.3mm) had the lowest growth during 2012. Based on the initial findings during the first season of this multiple season study, data suggests that black plastic and landscape fabric may be viable alternatives to herbicide applications for weed control North Dakota vineyards. While straw provided excellent weed control, its use caused decreases in vine growth during the first season.

CHARACTERIZATION OF AN INDIANA PALMER AMARANTH POPULATION RESISTANT TO GLYPHOSATE. Doug J. Spaunhorst*, William G. Johnson; Purdue University, West Lafayette, IN (51)

A Palmer amaranth population near Twelve Mile, Indiana was reported to survive multiple in-season glyphosate applications over a 5 year period. Therefore, the objectives of this experiment were to determine the level of glyphosate resistance and the effectiveness of other herbicides for the control of the Twelve Mile, Indiana Palmer amaranth population. In the first experiment, a glyphosate dose-response (2.5, 5, 10, 15, 20, 30, and 40 kg ha$^{-1}$) experiment was conducted and $GR_{50}$ and $GR_{90}$ values were determined from visual control ratings and dry weights 3 weeks after treatment. In the second experiment, two rates of glyphosate, fomesafen, dicamba, 2,4-D choline, glufosinate, and mesotrione were applied to examine the possibility of multiple resistance in the population. Based on visual ratings, $GR_{50}$ was 5.6 kg ha$^{-1}$ of glyphosate and $GR_{90}$ was 10.8 kg ha$^{-1}$ of glyphosate. The $GR_{50}$ for biomass was 4.4 kg ha$^{-1}$ of glyphosate and $GR_{90}$ was 14.9 kg ha$^{-1}$ of glyphosate. In the experiment evaluating control with other herbicides, poor Palmer amaranth control occurred in response to 0.1, 0.35, and 2.5 kg ha$^{-1}$ of mesotrione, fomesafen, and glyphosate; respectively. The greatest control was observed with dicamba or 2,4-D choline or with 1.2 kg ha$^{-1}$ of glufosinate. These experiments indicate that Palmer amaranth from Twelve Mile, Indiana is resistant to glyphosate. In response to poor control provided by fomesafen, additional studies will be conducted to examine this in more detail. In addition, 100% control of Palmer amaranth was achieved with 0.56 or 1.1 kg ha$^{-1}$ of dicamba or 2.2 kg ha$^{-1}$ of 2,4-D choline applied to plants no greater than 7 cm in height.

INHERITANCE OF ATRAZINE RESISTANCE IN PALMER AMARANTH. Mithila Jugulam*, Amar S. Godar, Curtis R. Thompson; Kansas State University, Manhattan, KS. (52)

Palmer amaranth (*Amaranthus palmeri*) is one of the major economically troublesome weeds of the U.S. Palmer amaranth populations resistant to atrazine were reported in 1990s in Kansas, however, underlying mechanism and inheritance of resistance is unknown. Atrazine resistance in the majority of weeds was reported to be due to an altered *psbA* gene that encodes D1 protein, the target site of atrazine in the chloroplast and hence, maternally inherited. The objective of the study was to determine if the atrazine resistance in Palmer amaranth populations from Kansas is maternally-inherited and due to an altered target-site. Thirty six plants from two populations that are segregating for atrazine resistance or susceptibility were clonally multiplied. Clones of these two populations were treated with 2140 g ai/ha of atrazine, and subsequently, 2 weeks after treatment (WAT), atrazine-resistant (AR) or –susceptible (AS) clones were identified from each population. Using male or female AR and AS clones, reciprocal crosses were performed and $F_1$ seed was produced. $F_1$ progeny were raised and treated with 4280 g ai/ha. Two WAT, progeny from the reciprocal crosses were found segregating for AR or AS, suggesting that the atrazine resistance in these Palmer amaranth populations is a nuclear inherited trait. Additionally, nucleotide sequence of both AR populations showed no mutation at Ser264 in chloroplastic *psbA* gene. Results from this research clearly suggest that atrazine resistance in these Palmer amaranth populations is a not a maternally transmitted and determined by non-target site-based mechanisms, possibly by enhanced metabolism of atrazine. Therefore, these populations also exhibit cross resistance to other families of PSII-inhibiting herbicides (non-triazines). The nuclear inheritance of the atrazine resistance in Palmer amaranth may facilitate rapid spread of resistance, and hence warrants effective management strategies to minimize the spread of resistance.

## BIOCHEMICAL BASIS FOR METABOLISM-BASED ATRAZINE RESISTANCE IN WATERHEMP.

Anton F. Evans*, Rong Ma, Jacqueline Janney, Brittany A. Janney, Dean E. Riechers; University of Illinois, Urbana-Champaign, IL (53)

Atrazine, a photosynthesis system II inhibitor, is one of the most commonly used herbicides in the United States for selective broadleaf weed control in corn (*Zea mays*). Detoxification of *s*-triazine herbicides is the result of increased glutathione *S*-transferase (GST) activity in atrazine-tolerant crops such as corn and grain sorghum (*Sorghum bicolor*) or in atrazine-tolerant weeds such as *Panicum* spp. GSTs detoxify herbicides by catalyzing the conjugation of reduced glutathione with herbicides containing electrophilic sites through nucleophilic substitution. The conjugated herbicide molecule is then either transported to the plant cell vacuole for further metabolic processing, or is sequestered from its plastidic site of action in the cell wall as bound residue. In atrazine-resistant populations of waterhemp (*Amaranthus tuberculatus*) identified from central Illinois, the lack of a mutation in the *psbA* gene (the target site for atrazine) and the rapid production of atrazine-glutathione metabolites in radiolabeled atrazine-treated plants indicated that enhanced metabolism is the major resistance mechanism in this waterhemp population. Our objectives were to quantify GST enzyme activity and identify atrazine-metabolizing GST isozymes to determine their biochemical roles in the rapid production of atrazine-glutathione conjugates in atrazine-resistant waterhemp populations from Illinois, and ultimately to understand the importance of specific GSTs in atrazine-resistance mechanisms in waterhemp. Partially-purified GST proteins were obtained from crude leaf extracts through ammonium sulfate precipitation and glutathione affinity purification. SDS-PAGE analysis and silver staining indicated the presence one major band at approximately 26 kDa, which is indicative of plant GST subunits. Using atrazine as a substrate, GST specific activities in partially-purified protein samples were up to three times greater in samples from the resistant populations compared with an atrazine-sensitive waterhemp population. These initial findings indicate that GSTs play a significant role in the overall metabolic pathway and resistance mechanism to atrazine in the two central Illinois waterhemp populations. Future work will consist of identifying and characterizing specific GST isozymes that can rapidly metabolize atrazine in the resistant populations from central Illinois.

## INFLUENCE OF SOIL RESIDUAL FOMESAFEN AND DICAMBA TANK-MIXTURES ON THE FREQUENCY OF PPO-RESISTANT WATERHEMP.

Theresa A. Reinhardt*, R. Joseph Wuerffel, Julie M. Young, Bryan G. Young; Southern Illinois University, Carbondale, IL (54)

Herbicide-resistant weed biotypes have narrowed herbicide options for weed management, especially in soybeans where postemergence options are already limited. Previous field studies suggest that preemergence (PRE) applications of fomesafen may select for waterhemp (*Amaranthus tuberculatus*) resistant to PPO-inhibiting herbicides. Specifically, the research further implies that fomesafen initially provides control at full use rates, but as less herbicide is available in the soil, PPO-resistant waterhemp will tend to emerge before susceptible waterhemp. Soil-residual tank-mix partners have been utilized for improved weed control and herbicide resistance management. Given the preliminary evidence that soil-residual herbicides seemingly select for resistant biotypes, the question remains: can improved control from soil-residual tank-mix partners also aid in reducing the selection for resistant biotypes? The implementation of new herbicide-resistance traits in soybean may allow for the soil-residual use of dicamba and the potential to tank-mix with other soil-applied herbicides to reduce the selection of resistant biotypes. Therefore, the present experiment quantified the selection for PPO-resistant waterhemp following a soil-residual application of fomesafen applied alone (1.32, 13.2, and 132g ai $ha^{-1}$) and in combination with dicamba (0.77, 7.7, 77 g ai $ha^{-1}$), respectively. The logistic rate structure aimed to simulate the degradation of herbicide in the soil, with the highest rate being one third of a full use rate. Tissue samples were taken from the first 20 emerging waterhemp plants in each treatment, including the non-treated control, and genotyped using an allele specific TaqMan assay to detect the codon deletion responsible for PPO resistance in waterhemp. Results indicated that applications of fomesafen alone at 132 g ai $ha^{-1}$ increased the frequency of PPO resistance in the emerging population, with 90% of the sample population having resistance compared to 25% of population in the untreated control. The addition of dicamba to fomesafen reduced the frequency of resistant waterhemp to 70% of the population. While this research demonstrates that the addition of dicamba may not fully reduce the selection for PPO-resistant biotypes, fomesafen and dicamba applied together at the highest rate provided considerable residual control of the resistant waterhemp. Therefore, these results further emphasize the importance of proactive herbicide resistance management by employing full use rates of soil-residual herbicides and the combination of multiple herbicide modes of action.

## EPSPS PRO106SER SUBSTITUTION IN A GLYPHOSATE RESISTANT GOOSEGRASS POPULATION FROM TENNESSEE.

Janel L. Huffman*[1], Chance W. Riggins[1], Lawrence E. Steckel[2], Patrick Tranel[1]; [1]University of Illinois, Urbana-Champaign, IL, [2]University of Tennessee, Jackson, TN (55)

Goosegrass (*Eleusine indica*) is a problematic summer annual weed that has a strong tendency to evolve resistance to herbicides. Previous studies have documented the occurrence of glyphosate-resistant (GR) goosegrass and, in at least some cases, resistance is due to an altered target site. In this study, a combination of genetic inheritance and molecular studies were utilized to investigate the glyphosate resistance mechanism in a GR goosegrass population from Tennessee. DNA sequencing revealed a nucleotide change at position 319 of the EPSPS gene from the resistant population, which leads to a Pro106Ser substitution in the EPSPS enzyme. Greenhouse studies were performed to determine if resistance was controlled by a single gene. $F_1$ populations were obtained by crossing glyphosate-susceptible (GS) individuals with GR individuals. The $F_1$ hybrids were selfed and 96 individuals from the resulting $F_2$ population were genotyped at the EPSPS locus by PCR amplification of specific alleles (PASA). Of these 96 plants, 31 were homozygous for the EPSPS Pro106Ser mutation, 49 were heterozygous, and 16 were homozygous for the wild type Pro106 codon. This ratio did not deviate from the expected ratio of 1:2:1 (p=0.1). The same plants also were treated with glyphosate at 350 g ae $ha^{-1}$. This herbicide rate, determined from preliminary experiments, discriminated GS and GR individuals. As expected, all plants genotyped as homozygous sensitive were severely injured by the herbicide. All 31 of the plants identified as homozygous for the Pro106Ser mutation survived the herbicide, and 27 of these plants showed little or no injury. All 49 plants genotyped as heterozygous for the EPSPS mutation also survived the herbicide. Most (39) of these plants displayed moderate injury, but 10 of these plants were more severely injured, and looked similar to homozygous sensitive plants. Based on this research, we conclude that a Pro106Ser EPSPS mutation is the primary and likely only GR mechanism in the Tennessee goosegrass population. However, further research is underway to directly test for the presence of any additional GR mechanisms in the population.

## DIFFERENTIAL RESPONSE OF LAMBSQUARTERS FROM KANSAS TO GLYPHOSATE.

Randall DeGreeff*, Amar S. Godar, Anita Dille, Dallas E. Peterson, J. Mithila; Kansas State University, Manhattan, KS (56)

Common lambsquarters (*Chenopidium album L.*) is an annual broadleaf weed in the goosefoot family (Chenopodiaceae), and is competitive in corn and soybean production in the United States. Lambsquarters is known to have elevated tolerance to several herbicides with different modes of action, including glyphosate. Previously, lambsquarters biotypes resistant/tolerant to glyphosate have been reported in Indiana and Ohio. Recently, in north central Kansas, a biotype of common lambsquarters was not controlled by a glyphosate application in a soybean field. The objective of this study was to determine the response of this lambsquarters (test biotype) to glyphosate tolerance. Greenhouse dose-response experiments and shikimate accumulation assay were conducted. Additionally, glyphosate uptake and translocation experiments were also conducted to determine if the elevated tolerance is due to altered absorption and/or translocation. All experiments were conducted using a susceptible biotype for comparison. Dose-response results indicated elevated tolerance to glyphosate in the test biotype based on the $GR_{50}$ (a dose causing 50% biomass reduction) values (373 g ae/ha for susceptible and 552 g ae/ha for test biotype). Similarly, the glyphosate tolerant biotype accumulated slightly less shikimate in the leaf discs compared to the susceptible biotype. Minimal differences were observed in $^{14}C$ glyphosate uptake and translocation between the two biotypes. Based on results from this research, lambsquarters biotype found in north central Kansas appears to have elevated tolerance to glyphosate. Weed management strategies need to be initiated to control acceleration of glyphosate tolerance in lambsquarters, before we see evolved resistance to glyphosate.

INHERITANCE OF GLYPHOSATE RESISTANCE IN KOCHIA. Kindsey Niehues*, J. Mithila; Kansas State University, Manhattan, KS (57)

Prolonged use of glyphosate in glyphosate-resistant (GR) crops has created selection pressure resulting in evolution of glyphosate resistance in several weeds, including kochia (*Kochia scoparia*), a competitive summer annual broadleaf weed. Previous research suggests that glyphosate resistance in kochia is determined by increased copy number of the gene coding for EPSPS (5-enolpyruvyl shikimate 3-phosphate synthase), the target site of glyphosate. However, the inheritance of glyphosate resistance is unknown. The overall objective of this research is to study the inheritance of glyphosate resistance in kochia populations from Kansas. Homozygous GR and susceptible (GS) parental lines were developed. Using these parental lines, F1 progeny were produced by reciprocal crosses. $F_1$ progeny was screened for glyphosate resistance and self-pollinated to generate F2 progeny. Shikimate level and gene copy numbers were determined. GR parental individuals possessed higher EPSPS gene copies (6-9), while the susceptible parents had only one copy. The $F_1$ progeny from reciprocal crosses survived various doses of glyphosate application and showed intermediate response to parents for shikimate accumulation and EPSPS gene copy number. The response of $F_1$ plants from reciprocal crosses to glyphosate demonstrates that glyphosate resistance in kochia is a nuclear inherited trait. $F_2$ progeny segregated 3:1 (Resistan :Susceptible) at field recommended dose of glyphosate application. The nuclear inheritance of glyphosate resistance will facilitate spread of this resistance both via pollen and seed in kochia.

MULTIPLE HEBICIDE-RESISTANT KOCHIA FROM KANSAS. J. Mithila*[1], Amar S. Godar[1], Randall S. Currie[2], Anita Dille[1], Curtis R. Thompson[1], Phillip W. Stahlman[3]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Garden City, KS, [3]Kansas State University, Hays, KS (58)

Kochia (*Kochia scoparia*) has been historically prone to evolve resistance to several herbicides, and previously, cases of ALS-inhibitor and triazine- resistant kochia biotypes were reported from Kansas. The objective of this study was to confirm multiple herbicide resistance in kochia biotypes from Kansas that survived field application of four different modes of action of herbicides, *viz.,* atrazine, chlorsulfuron, dicamba, and glyphosate. Four biotypes of kochia that survived applications of at least three of the above herbicides were collected from fields in western Kansas and transferred to a greenhouse. These plants were kept in isolation until maturity and seed was harvested separately from each plant (biotype #1, 2, 3 and 4). Six individual plants (10-12 cm tall) from each biotype were treated with 0.25-, 0.5-, 1-, 2- and 4-X labeled use rates of atrazine, chlorsulfuron, dicamba, and glyphosate including recommended adjuvants. Plant survival, visual injury and aboveground dry biomass were determined four weeks after treatment. Data from these experiments demonstrated that plants of the biotype #1 survived 4X dose of all four herbicides applied. Furthermore, all four biotypes survived at least 2X dose of chlorsulfuron, glyphosate and dicamba. These results confirm the presence of kochia biotypes with resistance to four different modes of action of herbicides in western Kansas. Multiple herbicide resistance in kochia is a serious threat to sustainable agriculture, especially in no-till system. Weed management programs in the region should include diversified tactics to effectively prevent evolution and spread of multiple herbicide resistance in kochia.

TRANSFER OF PHENOXY RESISTANCE FROM WILD RADISH TO CANOLA VIA EMBRYO RESCUE. Andrew Dillon*, Mithila Jugulam; Kansas State University, Manhattan, KS (59)

Phenoxy herbicides (e.g. 2,4-D, MCPA) are widely used in agriculture for selective control of broadleaf weeds. Wild radish (*Raphanus raphanistrum),* a problem weed in cereal crops, evolved resistance to 2,4-D due to intense selection pressure in western Australia. Weedy and wild relatives offer excellent genetic resources to transfer useful agronomic traits, including herbicide resistance, into crop species. Canola (*Brassica napus*), a widely grown oilseed crop in Brassicaceae family, and a relative of wild radish, is sensitive to phenoxy herbicides. The goal of this research was to transfer phenoxy resistance from wild radish into canola by traditional breeding, coupled with *in vitro* embryo rescue. Interspecific crosses were performed between *B. napus* and 2,4-D resistant *R. raphanistrum*. Approximately 50-100 embryos were excised from immature siliques produced from these crosses and cultured *in vitro.* Upon altering the cultural conditions as well as media composition, four $F_1$ hybrids were produced. One $F_1$ hybrid was subsequently established in soil. The $F_1$ plants will be evaluated for 2,4-D tolerance, fertility and DNA ploidy level. 2,4-D-tolerant and fertile hybrids will be used to introgress tolerant trait into canola through backcross breeding. Development of 2,4-D-tolerant canola cultivars may facilitate effective broadleaf weed control, necessitate less tillage for weed management, and provide herbicide rotation options to growers.

## EFFECT OF COVER CROP AND WINTER ANNUAL WEED REMOVAL TIMING AND SOYBEAN PLANTING DATE ON SOYBEAN YIELD. Deanne Corzatt*, Mark L. Bernards; Western Illinois University, Macomb, IL (60)

Many no-till fields in the Midwest have dense infestations of winter annual weeds. In addition, the prevalence of cover crops in Midwest corn (*Zea mays*) and soybean (*Glycine max*) rotations has recently increased. Cover crops and winter annual weeds fill a similar niche in the cropping system. Cover crops are promoted for improving soil structure, weed control, and soil fertility. However, recent reports suggest that not controlling the winter annual weeds until the time of corn or soybean planting can reduce yield 10% or more compared to controlling weeds in the late fall or early spring. The objective of this study was to compare the effect of removal time of winter annual weeds and cover crops on soybean yield as affected by soybean planting date and to evaluate if soybean yield responded differently to the two preceding vegetation regimes. The winter annual weeds prevalent within the study area were common chickweed (*Stellaria media*), field pennycress (*Thlaspi arvense*), and henbit (*Lamium aplexicaule*). Winter annual weeds were controlled in the cover crop study using glyphosate prior to establishing rye (*Secale cereale*) on November 21, 2012. Winter rapeseed (*Brassica napus*) was broadcast into standing rye in March 2013. Soybeans were planted at three times within the normal soybean planting season for central Illinois: early (April 29, 2013), middle (May 13), and late (June 3) in rows spaced 76 cm apart and at a seeding rate of 395,000 seeds ha$^{-1}$. Weeds were removed at four times relative to a specific planting date: Prior fall (Nov 20, 2012); 28 DBP (days before planting), 14 DBP and 0 DBP. Plots were kept weed free from the time of the initial removal until harvest. The effects of winter annual weed and cover crop removal relative to soybean planting date were not consistent in this one year study. Delaying winter annual weeds until planting reduced soybean yield relative to removing the weeds in the fall for the early and late planting date. Yield of the middle planting date was not affected by winter annual weed removal timing. In the cover crop study, delaying cover crop removal until the time of planting did not affect yield for the middle planting date, but reduced yield slightly for the late planting date. Delaying cover crop removal until two weeks prior to the early planting date increased yield.

## GLYPHOSATE-RESISTANT WATERHEMP RESPONSE TO GLYPHOSATE DOSES IN NEBRASKA. Jordan Moody*[1], Lucas Baldridge[1], Lowell Sandell[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (61)

*NO ABSTRACT SUBMITTED*

## MEASURING ECOLOGICAL FITNESS IN THE ABSENCE OF HERBICIDE SELECTION OF FIVE HERBICIDE-RESISTANCE TRAITS IN WATERHEMP USING A MULTI-GENERATION GREENHOUSE STUDY. Chenxi Wu*[1], Adam S. Davis[2], Patrick Tranel[1]; [1]University of Illinois, Urbana-Champaign, IL, [2]USDA-Agricultural Research Service, Urbana, IL (62)

The rapid evolution of herbicide resistance in waterhemp is an increasing threat to crop production in the midwestern United States. Since 1990, common waterhemp has evolved resistances to herbicides from six site-of-action families. Ecological fitness of herbicide resistance in the absence of herbicide selection is an important parameter for modeling and predicting the evolution of herbicide resistance. Unfortunately, there is limited fitness data available from robust study systems. In particular, few previous studies contain all three of the following features of a successful fitness study: 1) control of genetic background; 2) assessment of fitness throughout the plant life cycle; 3) assessment of fitness under competitive growth conditions. The objective of this study is to quantitatively measure the fitness of each of five herbicide resistance traits (ALS inhibitors, PPO inhibitors, HPPD inhibitors, atrazine, and glyphosate) in waterhemp through a multi-generational greenhouse study in the absence of herbicide selection pressure. The starting population was generated by crossing female plants sensitive to all five herbicides with male plants that collectively carried all five herbicide resistances. Resulting progeny were screened with discriminating rates of the herbicides and survivors were crossed to generate a population, designated $G_0$, segregating for all five resistances. In each of three replicate greenhouse rooms with a soil floor, 45,000 $G_0$ seeds were planted in a 3 m by 3 m area and favorable growth conditions were provided. Upon maturation of each of the three $G_0$ replicate populations, seeds were harvested to obtain replicate $G_1$ populations. This process will be repeated for six generations. Changes in the frequencies of each herbicide resistance trait over the multiple generations will be determined from both whole-plant herbicide treatments and molecular markers. Currently, the $G_2$ generation is growing in the greenhouse. Preliminary data on changes in herbicide resistance frequencies after two generations will be presented.

USE OF RESIDUAL HERBICIDES TO CONTROL WATERHEMP AND PALMER AMARANTH. Lucas Baldridge*[1], Jordan Moody[1], Strahinja Stepanovic[1], Lowell Sandell[1], Lawrence E. Steckel[2], Jason K. Norsworthy[3], Bryan G. Young[4], Kevin W. Bradley[5], William G. Johnson[6], Mark M. Loux[7], Vince M. Davis[8], Thomas W. Eubank[9], Greg R. Kruger[10]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Tennessee, Jackson, TN, [3]University of Arkansas, Fayetteville, AR, [4]Southern Illinois University, Carbondale, IL, [5]University of Missouri, Columbia, MO, [6]Purdue University, West Lafayette, IN, [7]The Ohio State University, Columbus, OH, [8]University of Wisconsin-Madison, Madison, WI, [9]Mississippi State University, Stoneville, MS, [10]University of Nebraska-Lincoln, North Platte, NE (63)

*NO ABSTRACT SUBMITTED*

WATERHEMP RESISTANCE TO POST EMERGENT APPLICATION OF HPPD HERBICIDES. Stevan Z. Knezevic*[1], Jon E. Scott[1], Aaron S. Franssen[2], Vinod K. Shivrain[3]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Syngenta Crop Protection, Seward, NE, [3]Syngenta Crop Protection, Vero Beach, FL (64)

Crop production systems in the United States are facing a major challenge with increasing number of weed species evolving resistance to herbicides. In 2009, waterhemp (*Amaranthus tuberculatus syn. rudis*) biotypes resistant to HPPD-inhibiting herbicides were first reported in Iowa and Illionois. Waterhemp has been reported to be resistant to three mechanism of actions in Nebraska; PSII, HPPD, and synthetic auxins-inhibiting herbicides. Field studies were initiated in 2012 and 2013 to determine level of waterhemp resistance to post-emergent applications of HPPD-inhibiting herbicides in a population reported from Nebraska. A total of five doses (0, 1X, 2X, 4X, and 8X) of suggested label rates of mesotrione, tembotrione, and topramezone were applied at two application timings (8 and 15 cm). Weed control was visually evaluated weekly until 26 DAT, and weed dry matter was recorded. Based on visual injury and dry matter reduction, dose response analysis was performed to determine $ED_{50}$, $ED_{60}$, and $ED_{80}$ values for control of 8 and 15 cm tall waterhemp with mesotrione, tembotrione, and topramezone. The estimated level of resistance at 26 DAT for 15 cm tall waterhemp to mesotrione, tembotrione, and topramezone was 13, 10, and 7 times the label rate, respectively. While levels of resistance to tembotrione and topramezone were not as high as mesotrione, the population was confirmed to be resistant. The use-pattern of HPPD herbicides should be carefully managed and an integrated weed management plan involving tillage and multiple mechanism of actions should be utilized.

DIFFERENTIAL RESPONSES TO ATRAZINE PREEMERGENCE AND POSTEMERGENCE IN TWO POPULATIONS OF ATRAZINE-RESISTANT WATERHEMP Â FROM ILLINOIS. Rong Ma*[1], Anton F. Evans[1], Shiv S. Kaundun[2], Brittany A. Janney[1], Dean E. Riechers[1]; [1]University of Illinois, Urbana-Champaign, IL, [2]Syngenta UK, Berkshire, England (65)

Waterhemp (*Amaranthus tuberculatus*) is a difficult-to-control weed in Illinois soybean and corn production, which is in part due to its outcrossing nature and high degree of genetic diversity. Atrazine is commonly used in corn (*Zea mays*) for selective preemergence (PRE) or postemergence (POST) control of annual dicot weeds. Previous research reported that elevated rates of metabolism via glutathione *S*-transferase (GST) activity contribute to atrazine POST resistance within two waterhemp (*Amaranthus tuberculatus*) populations designated MCR (from McLean County, IL) and ACR (from Adams County, IL). 4-Chloro-7-nitrobenzofurazan (NBD-Cl) was used as a GST inhibitor to test the hypothesis that the combination of NBD-Cl and atrazine can control MCR or ACR better than atrazine alone. Â Synergism of atrazine and NBD-Cl POST was detected in ACR seedlings, but not in MCR. In addition, a dose-response study indicated MCR was more resistant to atrazine PRE than either ACR or WCS (for Wayne County, IL herbicide-sensitive population). ACR responses, as measured by growth reductions of 50% ($GR_{50}$), 20% ($GR_{20}$), and 80% ($GR_{80}$) values, were intermediate when compared with MCR and WCS. Significantly, ACR is sensitive to atrazine PRE at a typical field-use rate of 2.0

lbs/acre. Furthermore, atrazine plus NBD-Cl applied PRE inhibited ACR seedling growth more than atrazine PRE alone. Therefore, the synergism observed between atrazine and NBD-Cl in ACR strengthens the conclusion that rapid metabolism is the main atrazine-resistance mechanism in ACR.Â  Additionally, atrazine PRE (with or without NBD-Cl) could still be utilized in integrated management programs for control of ACR in corn, although the duration of residual activity may be adversely affected. The GST(s) in MCR did not appear to be inhibited by NBD-Cl. These different responses to atrazine PRE in MCR relative to ACR indicate either the presence of unique GST isozyme(s) or higher GST expression in MCR, or that GST activity in ACR roots may be lower than in ACR leaves and MCR roots.

LANDSCAPE MOVEMENT OF 2,4-D RESISTANCE IN WATERHEMP. Lacy J. Valentine*[1], Zac Reicher[1], Patrick Tranel[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Illinois, Urbana-Champaign, IL, [3]University of Nebraska-Lincoln, North Platte, NE (66)

Greenhouse screenings were conducted to evaluate the movement of 2,4-D resistance in common waterhemp (*Amaranthus tuberculatus*) populations from southeast Nebraska. Common waterhemp seedlings were grown from plants collected in an 8 km radius of where the confirmed 2,4-D –resistant population was reported. Fourteen replications of 120 test populations were treated with twice the label rate of 2,4-D when plants reached 10-15 cm in height, while four test populations were untreated. Plants were evaluated 28 d after treatment and scored visually on a scale of 0%=no injury and 100%=complete plant death. A known resistant and known susceptible population was included in each replication and the observed injury averaged 84 and 22%, respectively. Within 250 meters of the known resistant population, plant injury averaged 36% and ranged from 8-86%. From 250 m to 1000 m, plant injury increased to 76% and ranged from 34-100%. Although resistance was anticipated to move in the east-northeasterly direction with the prevailing summer winds, no distinct pattern of movement of the resistant population was found. The results from this experiment provide evidence that 2,4-D resistance from the from original population has remained within 250 m of given population.

GROWTH RATE, DRY MATTER ACCUMULATION, AND SEED YIELD OF COMMON WATERHEMP. Joseph M. Heneghan*, William G. Johnson; Purdue University, West Lafayette, IN (67)

Common waterhemp (*Amaranthus rudis)* is a weed that has grown in prevalence in Indiana over the past 10 years. Research was conducted in order to better understand common waterhemp behavior and growth characteristics in Indiana. Glyphosate-susceptible plants were germinated in a greenhouse and transplanted to field conditions at the 5-10 cm height at a density of 8 plants/m$^2$. Plant height, number of nodes, leaf number and time of flower initiation were measured. Data was collected weekly until 8 WAP and then every other week until harvest. Average growth rate throughout the season was 2.5 cm/day with a maximum average weekly rate of 4.7 cm/day. Leaf numbers increased approximately 290% each week until 8 WAP. In this experiment plant height and number of nodes were visually observed to be related. Leaf number and percent flowering were also visually observed to increase rapidly at similar points in the growing season. There was an approximately normal distribution in both the male and female dry weight accumulations. A unique bi-modal distribution existed when seed yields were represented by weight, but a right skewed distribution when yields were represented by number of seeds per plant. The minimum seed yield was calculated to be 68,000 seeds per plant and maximum seed yield was calculated to be 886,000 seeds per plant. Yields by weight ranged from 17.7 g to 167.7 g. Understanding the growth characteristics and seed potential of common waterhemp can help in management decisions and herbicide application timings.

IMPACT OF EMERGENCE DATE ON REPRODUCTIVE POTENTIAL OF AMARANTHUS. Heidi R. Davis*, Reid J. Smeda; University of Missouri, Columbia, MO (68)

Amaranthus species such as common waterhemp (*Amaranthus rudis*) emerge throughout the growing season, competively reducing soybean yield and adding significantly to the soil seed bank. Although research on waterhemp management and resistance to herbicides is well documented, additional weed biology data are needed to ascertain the relationship of emergence date to plant growth and fecundity. In a field trial near Columbia, MO, common waterhemp was established at five dates from mid-May to mid-September in 2013. Plant height and number of nodes (potential lateral branches) were collected from six plants weekly until fall. As plants for each planting date initiated flowering, up to 55 plants were observed to assess the ratio of male to female plants. When greater than 80% of the seed were determined visually to be mature, six plants from each of the five replications for planting date were harvested and dry weight recorded. Seeds were extracted from plants to determine seed production. Final plant height ranged from 298 to 5 cm for plants established in mid-May and Mid-September, respectively. The number of nodes reflected the extent of branching, which contributes to the propensity for seed production. Average node numbers ranged from 64 to 8 for early versus later germinating plants. The number of centimeters for each node generated (lateral stem) declined for later versus earlier germinating plants (3.24 to 0.68). Common waterhemp is dioecious; female to male ratios ranged from 47:53 to 62:38 and did not appear related to the date of plant emergence. The number of days from emergence to flowering changed throughout the growing season; 69 days for plants emerging in mid-May plants and 34 days for plants emerging in mid-September. Mean whole plant dry weight at harvest was 619, 353, 180, 32, and 0.1 grams for waterhemp emerging from mid-May to mid-September. Seed were collected from all plants with changes in seed productivity for emergence date following the changes in plant dry weight. Early emerging waterhemp are most likely to exact competitive reductions in crop yields, but later emerging plants can still generate significant number of seeds to add to the soil seed bank.

EMERGENCE PATTERNS OF WATERHEMP IN NEBRASKA IN 2013. Chandra J. Hawley*[1], Lacy J. Valentine[2], Lowell Sandell[2], Amit J. Jhala[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (69)

*NO ABSTRACT SUBMITTED*

WATERHEMP CONTROL UNDER VARYING DROUGHT STRESS CONDITIONS WITH 2,4-D AND GLYPHOSATE. Joshua J. Skelton*, Brittany A. Janney, Dean E. Riechers; University of Illinois, Urbana-Champaign, IL (70)

Weeds under drought stress are more difficult to control with postemergence (POST) herbicides. In particular, glyphosate efficacy is greatly affected by drought stress, as both reduced foliar absorption and translocation have led to decreased weed control in field and greenhouse studies. Tank-mixing 2,4-D amine with glyphosate under drought-stressed conditions could potentially benefit growers by increasing control of glyphosate-sensitive or glyphosate-resistant weeds. Abscisic acid-induced stomatal closure (following 2,4-D treatment) may improve POST weed control under drought-stressed conditions because plant water content may increase or remain steady, potentially allowing for greater herbicide uptake and translocation. The objective of this research was to determine if 2,4-D (as the choline salt) can increase glyphosate efficacy on waterhemp (*Amaranthus tuberculatus*) under different levels of drought stress. Two different experiments were conducted using the same treatments, the first under optimal watering conditions and the second under varying levels of drought stress. Results from both experiments were inconsistent and therefore were analyzed separately. Under optimal watering conditions, waterhemp control with 2,4-D choline (267 g ai/ha) was greater than glyphosate (280 g ae/ha) or equal to glyphosate (840 g ae/ha) alone in one trial but was not significantly different in the second. Water content of plants treated with 2,4-D, either alone or tank-mixed with glyphosate (280 g ae/ha), was significantly higher than glyphosate (840 g ae/ha) applied alone or tank-mixed with 2,4-D, while maintaining similar waterhemp control. Under drought-stressed conditions, all herbicide treatments controlled waterhemp greater when more soil water was present. Plant water content was increased by 2,4-D alone or when tank mixed with glyphosate (280 g ae/ha) but only under the highest water level (40 mL/day). POST waterhemp control was greatest when adequate soil water levels were present. In the drought study, greater waterhemp dry matter reduction for all treatments occurred at the highest soil water level, but control declined as soil water levels decreased. 2,4-D increased plant water content and displayed similar control levels as glyphosate (both rates), but only when plant-available water (PAW) was saturated or at the highest daily water amount. Under drought-stressed conditions, tank mixing 2,4-D choline with glyphosate increased waterhemp control but did not increase plant water content. Further research into whether 2,4-D interacts with stress hormones in the plant and/or with glyphosate to increase waterhemp control under drought-stressed conditions is necessary to understand the underlying mechanisms for potential additive or synergistic interactions in a tank mix.

IDENTIFYING GENDER-SPECIFIC DNA MARKERS IN WATERHEMP. Ahmed Sadeque*, Patrick J. Brown, Patrick Tranel; University of Illinois, Urbana-Champaign, IL (71)

Herbicide resistance and multiple resistance is common in waterhemp. One characteristic contributing to its success at evolving resistance is its dioecious nature. Dioecy is also present in a few other *Amaranthus* species (e.g., Palmer amaranth), but little is known about the genetics, molecular biology, and evolution of this trait within the genus. In current work we are utilizing Restriction-site Associated DNA sequencing (RAD-seq) to gain insights into the sex-determination mechanisms in waterhemp. Equal number of male and female DNA samples, 200 each, was used to construct RAD-seq libraries. This was accomplished by subjecting DNA samples to restriction followed with barcoding the restricted fragments through adaptor ligation. The samples were then pooled, amplified and cleaned to establish RAD-seq libraries. Afterwards the libraries were sequenced using the Illumina platform. Sequence data will be analyzed using well-established pipelines such as STACKS or TASSEL (Trait Analysis by aSSociation, Evolution and Linkage) with a goal of identifying gender-specific markers. PCR probes will be developed for candidate markers and used to confirm the gender specificity of the markers using different waterhemp populations. In the near term, gender-specific markers will be useful to the waterhemp research community (e.g., in selecting plants for crossing experiments). In the long term, this research will provide tools to begin detailed investigations of the molecular biology and evolution of dioecy in *Amaranthus*. Ultimately, manipulation of gender expression in waterhemp could provide a novel weed management strategy.

CHARACTERIZATION OF ILLINOIS POPULATIONS OF WATERHEMP AND PALMER AMARANTH FOR HERBICIDE MODE-OF-ACTION SENSITIVITY AND SOIL RESIDUAL ACTIVITY. Jamie L. Long*, Julie M. Young, Bryan G. Young; Southern Illinois University, Carbondale, IL (72)

Waterhemp (*Amaranthus tuberculatus*) and Palmer amaranth (*Amaranthus palmeri*) are troublesome weeds that continue to spread throughout the Midwest.  The increasing prevalence of glyphosate resistance in both these species has emphasized the need for effective soil residual herbicide applications in soybean.  Field trials were conducted in 2012 and 2013 near Collinsville (Palmer amaranth) and DeSoto, IL (waterhemp) to compare residual activity of preemergence herbicides commonly used in soybean.  In a separate experiment, herbicides from various mode-of-action groups were evaluated for postemergence control of Palmer amaranth at Collinsville, IL in 2012 and 2013.  In the postemergence experiment, control of Palmer amaranth 8 to 10 cm in height was less than 70% from glyphosate at 1700 g ae $ha^{-1}$ and less than 20% from imazethapyr and imazamox, indicating that in this population individual plants were resistant to glyphosate and ALS-inhibiting herbicides.  The HPPD-inhibiting herbicides mesotrione and isoxaflutole provided less than 75% control of Palmer amaranth.  Glufosinate and paraquat provided good initial control of Palmer amaranth although control was reduced at later evaluation dates due to regrowth and new emergence.  Residual control of waterhemp was greatest in both years from a premix of sulfentrazone plus cloransulam and combinations of a PPO-inhibiting herbicide and a seedling shoot inhibitor.  Pyroxasulfone was the only single herbicide that consistently provided high levels of residual waterhemp efficacy.  Waterhemp control from the photosystem II inhibiting herbicides linuron and metribuzin alone and in combination with a seedling shoot inhibitor was inconsistent across years.  In 2012, none of the residual herbicides evaluated provided greater than 70% control of Palmer amaranth at 42 days after application.  However in 2013, Palmer amaranth control was at least 90% at 56 days after application from herbicide treatments which included a PPO-inhibiting herbicide.  Soil residual herbicides are a critical component of effective Palmer amaranth and waterhemp management in soybean since effective postemergence control options are limited.  Combinations of a PPO-inhibiting herbicide with a seedling shoot inhibiting herbicide were among the most effective options for control of both species.

EMERGENCE PATTERNS OF WATERHEMP AND PALMER AMARANTH IN THE SOUTHERN AND MIDWESTERN U.S. Lucas X. Franca*[1], Bryan G. Young[1], Jason K. Norsworthy[2], Thomas W. Eubank[3], Lawrence E. Steckel[4], Mark M. Loux[5], William G. Johnson[6], Vince M. Davis[7], Reid J. Smeda[8], Greg R. Kruger[9]; [1]Southern Illinois University, Carbondale, IL, [2]University of Arkansas, Fayetteville, AR, [3]Mississippi State University, Stoneville, MS, [4]University of Tennessee, Jackson, TN, [5]The Ohio State University, Columbus, OH, [6]Purdue University, West Lafayette, IN, [7]University of Wisconsin-Madison, Madison, WI, [8]University of Missouri, Columbia, MO, [9]University of Nebraska-Lincoln, North Platte, NE (73)

The continued spread of glyphosate-resistant waterhemp and Palmer amaranth has complicated weed control efforts in soybean production. A thorough understanding of the biology of these species is fundamental in developing effective management strategies. Determining emergence patterns across multiple geographies and the influence of tillage on weed emergence will allow control strategies to be implemented at the most effective timing. The objective of this research was to characterize the emergence patterns of waterhemp and Palmer amaranth across geographies as influenced by tillage. Field experiments were initiated in the spring of 2013 on indigenous populations of pigweed in Illinois, Arkansas, Indiana, Missouri, Nebraska, Ohio, Tennessee, and Wisconsin. The experimental design was a randomized complete block with three tillage treatments: no-tillage, tillage on May 1, and tillage on June 1. *Amaranthus* seedlings were identified and counted in the center 1 $m^2$ quadrat of each plot weekly from April until November with *Amaranthus* seedlings removed from the sample area following enumeration. In order to evaluate the influence of environmental changes on weed emergence, soil temperature and moisture were recorded throughout the experiment by probes buried 2.5 cm deep in the plot area. In southern Illinois waterhemp emergence was first observed in early May and extended until the beginning of October. However, 90% of the total waterhemp emergence occurred by the last week of June.
In contrast, the duration of waterhemp emergence in Wisconsin was relatively short with germination observed from late June through September and 90% of total emergence observed by the beginning of August. In southern Illinois, Palmer amaranth emergence started one week after waterhemp but extended for a longer period with emergence continuing into late October. A similar period of Palmer amaranth emergence was observed in Indiana with 90% of total emergence observed by the second week of July. In Tennessee, Palmer amaranth emergence started in the second week of April and continued until the first week of September with 90% of total seedlings emerged by the second week of July. Geographic differences in peak waterhemp emergence will necessitate the use of different management strategies for effective control of this species. Although Palmer amaranth and waterhemp emergence continued into the fall months, the use of effective soil residual herbicides to control these species until early July could reduce overall emergence by 90%.

HISTORICAL DISTRIBUTION OF GIANT RAGWEED AND COCKLEBUR IN THE NORTH CENTRAL REGION. Ramarao Venkatesh*[1], Robert A. Ford[1], Emilie E. Regnier[1], Steven K. Harrison[1], Christopher Holloman[1], Robin Taylor[2], Florian Diekmann[1]; [1]The Ohio State University, Columbus, OH, [2]Texas A&M University, Temple, TX (74)

Several reports have indicated that giant ragweed (*Ambrosia trifida*) is one of the most difficult weeds for growers to control in the Midwest corn and soybean fields. The objective of this ongoing study is to determine the distribution of giant ragweed and factors hypothesized to contribute to its spread over space and time. To collect data on hypothesized causal factors, we are using several sources including scientific literature, herbaria, available GIS maps, and a survey instrument. In this study, herbaria specimens were used to reconstruct the historical spread of giant ragweed in the North Central Region. Herbaria data presents many interpretive challenges. Some of the collection biases include non-random sampling and unequal sampling effort over time. In order to account for the collection biases, we compared collection effort of giant ragweed to that of common cocklebur (*Xanthium strumarium*) because it is a similar native species. A database incorporating 1,795 giant ragweed specimens and 1,107 cocklebur specimens from 157 herbaria was constructed. Based on the habitat information from the specimen labels, habitat data were broadly categorized into riparian and upland. The sampling location and year of sampling indicated on the specimen label data were incorporated into ArcGIS 10.1® for reconstructing historical maps. The oldest specimen of giant ragweed in the North Central region was recorded in Illinois in 1852 and for cocklebur in Ohio in 1871. Maps indicating the spatial distribution and chronology of the two species were constructed with data from 1850 to the present. In addition, the total number of specimens collected over the region for both the species was plotted from 1850 to the present. From 1875 to 1895, common cocklebur collection effort was greater compared to giant ragweed. Giant ragweed was collected at a higher rate from 1926-1946. The collection effort for common cocklebur was greater for the remaining time period. The results did not indicate that giant ragweed invasiveness in the past 20-30 years was greater than common cocklebur based on collection effort. The proportion of specimens collected for giant ragweed in upland habitats overtook riparian habitats starting in the 1930's. The historical habitat trend suggests that the ragweed habitat shifted from riparian to upland over the collection period analyzed. This confirms that ragweed was initially a weed in riparian habitats and in the past few decades has adapted and became more prevalent in upland environments.

GIS ANALYSIS OF GLYPHOSATE RESISTANCE IN GIANT RAGWEED . Robert A. Ford*[1], Ramarao Venkatesh[1], Emilie E. Regnier[1], Steven K. Harrison[1], Christopher Holloman[1], Robin Taylor[2], Florian Diekmann[1]; [1]The Ohio State University, Columbus, OH, [2]Texas A&M University, Temple, TX (75)

Glyphosate resistance in giant ragweed (*Ambrosia trifida)* has been documented across the Midwest. Factors associated with the development of glyphosate resistance are important to understand because this information could be used to find unreported resistant populations and to predict likely locations for resistance development. We hypothesized that direction of river flow was positively correlated with direction of spread because giant ragweed is primarily a riparian species and its seeds can be easily transported via water. We also hypothesized that areas with more crop acreage managed with reduced tillage would have more resistance cases because previous studies have indicated this tillage type to be more conducive to giant ragweed establishment. With wide adoption of glyphosate resistant soybeans, soybean acreage was also hypothesized to contribute to resistance development. The study area consisted of Ohio, Illinois, and Indiana. To perform exploratory analysis, we used binary logistic regression to test the dependence of glyphosate resistance on various independent variables across all three states. The independent variables tested included dispersal pathways (roads, railroads, rivers), tillage practices (conventional, reduced, mulch-till, ridge-till, and no-till), glyphosate use (kg per km$^2$) and crop species (corn, soybean, wheat, cotton, grain sorghum). Twenty-eight confirmed cases of resistance constituted our data set. The results showed that no-tillage soybean acres per square kilometer, glyphosate usage per square kilometer, and western flowing rivers were significantly correlated with the occurrence of resistance. These results support the hypothesis that resistance is spreading westward through waterways but does not support the hypothesis that resistance is correlated with reduced tillage crop acreage. They also support the hypothesis that soybean acreage contributes to resistance development. Resistance correlation with no-tillage soybeans might be explained by the fact that no-tillage fields typically utilize more glyphosate than conventional fields. This preliminary study will be used as a basis for a larger study incorporating a larger geographic area and more resistance cases.

METAGENOMIC EVALUATION OF RHIZOSPHERE MICROBIAL COMMUNITY DYNAMICS IN GLYPHOSATE-TREATED GIANT RAGWEED BIOTYPES. Jessica R. Schafer*, Steve G. Hallett, William G. Johnson; Purdue University, West Lafayette, IN (76)

In a previous study, glyphosate-susceptible and -resistant giant ragweed (*Ambrosia trifida* L.) biotypes grown in sterile field soil survived a higher rate of glyphosate than those grown in unsterile field soil. The roots of the susceptible biotype were colonized by a larger number of soil microorganisms than those of the resistant biotype, when treated with 1.6 kg ae ha$^{-1}$ glyphosate. Thus the ability of the resistant biotype to tolerate a glyphosate application may involve differences in the interaction between the roots and soil microbial communities. Therefore, the objective of this study was to evaluate differences in the rhizosphere microbial community composition of glyphosate-susceptible and -resistant giant ragweed biotypes 3 days after a glyphosate treatment (DAT). Giant ragweed biotypes were grown in the greenhouse in unsterile field soil and glyphosate was applied at either 0 or 1.6 kg ha$^{-1}$. At 3 DAT rhizosphere soil was sampled, and DNA was extracted, purified, and sequenced utilizing Illumina Genome Analyzer next-generation sequencing. Metagenomics analysis was conducted to evaluate the taxonomic distribution of the microbial community, diversity, genera abundance, and community structure within the rhizosphere of the two giant ragweed biotypes in response to a glyphosate application. In both biotypes bacteria comprised approximately 96% of the total microbial community, and small changes in the distribution of some microbial phyla and genera were observed. However, we did not observe large differences in the diversity or structure of soil microbial communities among our treatments. The results of this study indicate that challenging giant ragweed biotypes with glyphosate causes perturbations in rhizosphere microbial communities, but that the biological relevance of microbial community data obtained by next-generation sequencing needs to be interpreted with caution.

## GIANT RAGWEED RESISTANCE TO GLYPHOSATE IN NEBRASKA. Stevan Z. Knezevic*[1], Jon E. Scott[1], Avishek Datta[2]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Asian Institute of Technology, Bangkok, Thailand (77)

Extensive use of glyphosate and Roundup Ready crops has changed farming practices over the last 15 years. Repeated use of glyphosate on over 100 million hectares has developed glyphosate resistance in 13 weed species in the United States. The current suspected glyphosate resistant (GR) giant ragweed population was found in a corn and soybean production system with history of glyphosate use for weed management in David City, NE. Therefore, field experiments were conducted in 2012 and 2013 to determine the level of glyphosate resistance in the suspected GR giant ragweed population in David City, NE. The experiments were conducted twice with four replications. Trial by treatment interactions was not significant therefore; data were combined over experimental runs and years. Weed control was assessed visually at 7, 14, and 21 DAT, and dry matter data was recorded. Dose response studies were conducted with five glyphosate rates (0, 1X, 4X, 8X, and 16X of label rates) applied postemergence at two application timings (10 and 20 cm). Glyphosate resistance was determined by the $ED_{80}$ and $ED_{90}$ values of the population. The estimated level of glyphosate resistance based on $ED_{90}$ values at 21 DAT for 10 and 20 cm tall giant ragweed was 14X and 36X, respectively. To achieve 90% control of this population, at least 14 times the label use-rate (1060 g ai/ha) was needed, indicating that the suspected giant ragweed population was glyphosate-resistant.

## EMERGENCE TIME OF SUMMER AND WINTER ANNUAL WEEDS IN THE MIDWESTERN USA. Rodrigo Werle*[1], Lowell Sandell[1], Mark L. Bernards[2], Doug Buhler[3], Bob G. Hartzler[4], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Western Illinois University, Macomb, IL, [3]Michigan State University, East Lansing, MI, [4]Iowa State University, Ames, IA (78)

Annual weed species are a major pest problem in row crops across the Midwestern USA. Knowledge on the timing and sequence of weed species emergence under field conditions can help growers to decide the best time for management practices. The objective of this study was to develop a practical tool for forecasting time of emergence of annual weed species common to Midwest agriculture. First and second year seedbank emergence of 23 summer annual weed species (study 1) and first year seedbank emergence of 9 winter annual weeds (study 2) was evaluated. For study 1, field experiments were conducted between 1996 and 1999 near Ames, IA. In the fall of 1996 and again in 1997, 1,000 seeds for most species were planted in plastic crates. Seedling emergence was counted weekly for a two year period following seed burial (starting early-spring). Soil temperature at 2 cm depth was estimated using $STM^2$ software. For study 2, experiments were established at Lincoln, Mead, and at two sites (irrigated and rainfed) near Clay Center, NE, in 2010 and 2011. In July of each year, 1,000 seeds of each species were planted in mesh baskets. Soil temperature at 2 cm depth was recorded. Emerged seedlings were counted and removed from the baskets on a weekly basis until no additional emergence was observed in the fall, resumed in late winter and continued until emergence ceased in the summer. A Weibull function was selected to fit cumulative emergence on thermal time (TT). A $T_{base}$ = 9 C was used to accumulate heat units to describe the emergence pattern of summer annual weeds, starting January 1. For winter annual weeds, $T_{base}$ = 0 C and August 1 as the starting date for TT accumulation were used. Using a constant $T_{base}$ enabled us to understand summer and winter annual weed emergence sequence under field conditions. Summer annual weeds were classified as early, middle, and late emerging species and winter annual weeds were classified as fall-, mostly fall-, and mostly spring-emerging species. The results of this research provide robust information on the prediction of the time of summer and winter annual weed emergence, which can be used to schedule weed and crop management.

## DEFINING THE WEED HOST RANGE OF *CLAVIBACTER MICHIGANENSIS* SUBSP. *NEBRASKENSIS*, CAUSAL AGENT OF GOSS'S WILT OF CORN. Joseph Ikley*, Kiersten Wise, William G. Johnson; Purdue University, West Lafayette, IN (79)

Goss’s bacterial wilt and leaf blight of corn is caused by the bacterium *Clavibacter michiganensis* subsp*. nebraskensis* (Cmn). Cmn has been documented to cause up to a 44% yield loss in corn and has become widespread throughout the Midwest. Currently, there are no effective chemical treatments for control of this disease. Planting hybrids that have genetic resistance to Cmn, tillage, and rotating to a non-host crop are currently the best management options. Shattercane (*Sorghum bicolor*) and four common foxtail (*Setaria*) species have been documented as being alternate hosts of Cmn.

Giant foxtail (*Setaria faberi*) is a late season escape in 10% of soybean fields in Indiana, and the presence of this weed in fields could potentially negate the benefits of cultural practices for Cmn management. Controlling these weed hosts can serve as another method to reduce inoculum levels in fields. The objective of this study was to determine if 13 common weed species and two commonly used cover crops are hosts of Cmn. In the greenhouse, plants were inoculated with a suspension of 1.0 x $10^8$ colony-forming units (CFU) of Cmn per mL. Percent of symptomatic leaf area was visually estimated 7 days after inoculation. Symptomatic and asymptomatic plants were subjected to serological testing, examined for bacterial streaming, and leaf tissue was plated onto Cmn-selective medium. Recovered bacteria from plating were Gram tested and will be sequenced and phenotyped to confirm identity as Cmn. Results indicate that the weeds johnsongrass (*Sorghum halepense*) and large crabgrass (*Digitaria sanguinalis*), and the cover crop annual ryegrass (*Lolium multiflorum*) are newly confirmed hosts of Cmn.

## INFLUENCE OF CEREAL RYE AND ANNUAL RYEGRASS COVER CROPS ON MANAGEMENT OF GLYPHOSATE RESISTANT HORSEWEED. Tyler A. Johnson*, Mark M. Loux; The Ohio State University, Columbus, OH (80)

Horseweed (*Conyza canadensis*) populations with resistance to glyphosate have been a problem in the Midwestern United States for more than a decade. Soybean growers continue to have problems obtaining consistently effective control of these populations, even with comprehensive herbicide programs. There has been a general increase in the acres planted with winter cover crops in Ohio, and there is hope that the integration of cover crops in horseweed management programs can improve control. Results of previous research have shown that cover crops can reduce horseweed germination in the spring, and compete with the weed for essential nutrients. Of the viable cover crops for the Midwest, cereal rye (*Secale cereale*) and annual ryegrass (*Lolium multiflorum*) are well suited because of the species' winter hardiness, biomass accumulation, and in the case of cereal rye, allelopathic activity. Field studies were conducted in 2012/2013 to determine the effect of cereal rye and annual ryegrass on horseweed population density, the control provided by herbicides, and soybean grain yield. The studies were conducted on grower's fields that were naturally infested with horseweed, and the cover crops were planted in early September to mid-October. There were two annual ryegrass sites (Henry and Bouic) and a cereal rye site (Vollrath). The treatment design included the following factors: (1) late fall application of 2,4-D vs. none; (2) no cover vs early-spring termination (burndown) of the cover with glyphosate vs termination one week prior to planting; and (3) inclusion of herbicides in the burndown application that have residual activity on horseweed vs. none. Measurements included population density of the cover at the time of termination, horseweed population density at various times from late fall through soybean harvest, horseweed control, and soybean population density and yield. Results from early June and late September are discussed here. All counts of horseweed were done in 10 $m^{-2}$ at each location. The significant effects of those horseweed counts were the same for all three locations in that the highest number of horseweed were observed in the treatment of fall kill date, no fall 2,4-D application, and no residual herbicide. The same effects of the treatments were observed in the late September counts as well. The only difference in that Bouic showed no significant effect while Henry and Vollrath did. The treatment with the lowest number of horseweed for the June and September counts were the same as well. Late spring cover removal, fall 2,4-D application with residual activity had the best results for controlling horseweed at all locations.

## IMPACT OF WEED MANAGEMENT AND NITROGEN RATE ON NITROUS OXIDE EMISSIONS IN CORN. Rebecca R. Bailey*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (81)

Nitrous oxide ($N_2O$) is a potent greenhouse gas. Both nitrogen (N) fertilization and weed management are critical elements to profitable corn production. $N_2O$ emissions increase with increasing N rates, and also with increasing soil moisture. Weeds compete with crops for both soil available N and water before they are terminated with postemergence (POST) herbicides. By reducing soil N and water, we hypothesize that weeds could potentially reduce $N_2O$ emissions while growing. However, previous research indicates that plant residues can increase $N_2O$ emissions, and thus weed residues remaining on the soil surface after POST herbicide termination may also contribute to higher emissions by later increasing soil moisture and encouraging N cycling. To investigate the effects of weed management and N rate on $N_2O$ emissions in corn, a field study was conducted in 2013 at sites located in Arlington and Janesville, Wisconsin. The study was a randomized complete block design with four replications at each site. Treatments were arranged in a 2x3 factorial with two levels of weed management accomplished by either preemergence (PRE) plus POST application or POST-only application, and N rates of 0, 90, or 180 kg N ha$^{-1}$. Corn was planted on June 4 in Arlington and on May 16 in Janesville. Just after planting, PRE treatments of 0.0164 kg ha$^{-1}$ saflufenacil + 0.146 kg ha$^{-1}$ dimethenamid-P and N as urea were applied. POST applications of glyphosate at a rate of 0.87 kg ae ha$^{-1}$ were made when weeds were 10-15 cm tall. As the weeds died, the residues were left on the soil surface. Gas samples were collected from static chambers placed within each plot. Gas samples were collected weekly from planting until the POST timing, twice a week for the two weeks after POST, and every two to three weeks until mid-September. Data were subjected to ANOVA in a mixed model procedure with location treated as a random effect. The weed management by N rate interaction was not significant (p = 0.6075). Total $N_2O$ emissions from planting to mid-September increased with increasing N rate (p <0.0001). Emissions were 53.3, 106.0 and 133.6 mg $N_2O$-N m$^{-2}$ for the 0, 90, and 180 kg N ha$^{-1}$ rates, respectively, but weed management had no effect (p = 0.9667). Furthermore, there was no difference in $N_2O$ emissions between PRE+POST vs. POST-only management strategies before termination (from planting to POST timing) (p = 0.9630) or after termination (from POST timing to mid-September) (p= 0.9348). Corn yield increased using a PRE+POST vs. POST-only herbicide strategy (13,630 vs. 12,420 kg ha$^{-1-}$) (p= 0.0118) and also with increasing N rate with 10,610, 13,530, and 14,940 kg ha$^{-1}$ for the 0, 90, and 180 kg N ha$^{-1}$ rates, respectively (p<0.0001). These results align with previous studies regarding the influence of N rate on $N_2O$ emissions and yield. However, we conclude that a PRE+POST vs. POST-only weed management strategy did not significantly affect $N_2O$ emissions in corn this year. More replication is needed and these studies will be repeated in 2014.

HERBICIDE CARRYOVER EVALUATION IN COVER CROPS FOLLOWING CORN AND SOYBEAN HERBICIDES. Daniel H. Smith*[1], Travis Legleiter[2], Elizabeth J. Bosak[1], William G. Johnson[2], Vince M. Davis[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Purdue University, West Lafayette, IN (82)

Cover Crops are a growing interest for corn and soybean producers in the North Central region due to the benefits of reducing soil erosion, providing and savaging nutrients, and increasing soil organic matter. This study was conducted to determine whether common soil applied herbicides with residual weed control properties applied in the spring during the establishment of corn and soybean crops affect the subsequent establishment of cover crops in the fall. Corn and soybean plots with glyphosate-resistant cultivars were planted at Arlington Agricultural Research Station, Arlington, WI on June 2, 2013. There was one corn and one soybean trial each with fourteen herbicide treatments applied at common labeled rates and timings. Treatments were replicated four times. Each crop included a control treatment with no residual herbicide applied, but weeds were managed with postemergence (POST) glyphosate for all treatments as needed to remove any effects from weeds. Both trials were harvested for silage near the beginning of September, and seven different cover crop species and/or varieties were seeded uniformly across all herbicide treatments. The cover crops included tillage radish (*Raphanus* sp.), crimson clover (*Trifolium incarnatum*), cereal ryegrass (*Secale cereal*), 70% oat (*Avena sativa*) plus 30% peas (*Pisum sativum)* mixture, and three annual ryegrass (*Lolium multifloram*) varieties. The annual ryegrass varieties included ‘Bruiser’ and ‘King’, diploids, and a tetraploid. Nearly two months after seeding, the cover crops were evaluated for herbicide injury with digital image analysis for percent cover and by weighing total dried biomass collected from a 0.25m$^2$ quadrat. Herbicide injury included the evaluation of plant stunting and loss of plant greenness. Cereal rye was the only cover crop not significantly impacted by the herbicide treatments applied in the corn or soybean trials (both p-values < 0.0001). All other cover crops had significantly reduced biomass (P < 0.05) and percent cover (P < 0.05) for at least one of the residual herbicide treatments applied in the corn and soybean trial. Our preliminary results suggest that the establishment of many different cover crops can be adversely affected by several commonly used corn and soybean herbicides, but the severity of damage will be cover crop and herbicide combination specific. More research will be needed to establish best management practices for farmers interested in the use of cover crops following silage harvest.

WINTER ANNUAL WEED SUPPRESSION WITH OILSEED RADISH. Sandler Leah*, Kelly Nelson; University of Missouri, Columbia, MO (83)

The wild radish is a prominent weed in the southeastern United States, and thus it could be used as an allelopathic weedy cover crop within cropping systems if it was found to suppress weed emergence or growth without adversely affecting crops. Oilseed radishes are a cover crop and have been promoted to increase soil aeration, suppress weeds, and increase yields of the subsequent rotational crop. Cover crops can provide several benefits for a farmer. By planting something on what could possibly be bare soil, nutrients can be immobilized, soil conserved, and additional forage can be grown for cattle in some instances. Cover crops may also provide winter annual weed suppression. This research sought to determine if the oilseed radish did provide weed control. Tillage radishes were no-till planted or planted following tillage in Northeast Missouri at 10 kg $ha^{-1}$ in 2011 and 2012 on 1 September (early planting date) and later on 26 September 2011 (corresponding with the first corn harvested on the farm). Weed suppression was visually rated at a scale of 0 (no control) to 100% (complete weed suppression) and weed samples were collected in the spring to determine weed (henbit and chickweed in 2011 and downy brome in 2012) suppression due to radish interference. In 2012, planting date of the oilseed radish effected spring control of common chickweed and henbit with the early planting of radishes suppressing common chickweed and henbit 76 to 77%, while dry weights were reduced up to 88% on 22 March There was no effect of grazing on common chickweed and henbit control, but total weed dry weight was reduced 47% by grazing. Similarly, in 2013, the radishes suppressed common chickweed by 84% with 86% henbit control on the earlier planting date compared to the 43% of the later planted radishes. Results from this research showed that with good oilseed radish establishment in the fall, provided suppression of common winter annual weeds.

## IMPACT OF COVER CROPS ON WEED DYNAMICS IN ORGANIC DRY BEANS. Erin C. Hill*, Karen A. Renner, Christy L. Sprague; Michigan State University, East Lansing, MI (84)

Cover crops have the potential to enhance crop rotations by increasing crop diversity and maintaining or improving ecosystem quality when cash crops are not present. When dry beans are part of a rotation, their later planting date (mid-June, Michigan) allows more time for spring growth of cover crops compared with crops such as corn and soybean. The objective of this study was to assess the influence of cover crops on weed pressure and nitrogen cycling in subsequent organic dry beans. Field experiments were conducted from 2011 through 2013 to determine the effect of cover crops on weed populations in organic dry beans. This research was designed as a two level experiment with main sites and satellite sites. The two main sites (6 site-years) were located on Michigan State University organic research farms and included four cover crops treatments: medium red clover, oilseed radish, rye, and no cover. The 9 satellite sites (totaling 18 site-years) were located in Michigan organic farmers' fields. Each satellite site had one cover crop treatment (clover, oilseed radish, or rye) and one no cover treatment. Both main and satellite sites were organized as randomized complete blocks with three to four replications. Weeds were managed uniformly by producers at each site using various cultivation tools. Weed density and biomass within the bean rows were sampled using three 0.12 $m^2$ quadrats (15 cm wide by 76 cm long) at both the V2 and R1 stages of bean development for all sites. At the main sites, beans planted following clover had greater weed biomass than the other treatments 33% of the time. At the satellite sites, there was more weed biomass in the beans planted into clover residues compared with no cover 17% of the time. Conversely, weed biomass was shown to be lower following rye compared with no cover crop 17% of the time at both the main and satellite sites. Adding cover crops to a rotation prior to dry beans provides many benefits, including nutrient and soil retention, and does not increase weed infestations, with the exception of red clover.

## FITNESS OF SORGHUM, SHATTERCANE AND THEIR F2 HYBRID PROGENY. Jared J. Schmidt*[1], Scott Sattler[2], Diana Pilson[1], Aaron J. Lorenz[1], Jeff f. Pedersen[2], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]USDA-ARS, Lincoln, NE (85)

Sorghum (*Sorghum bicolor* subsp. *bicolor*) can interbreed with its close weedy relative shattercane (*S. bicolor* subsp. *drummondii*). Introduction of crop alleles into weedy populations can affect the success of the weedy population. Shattercane x sorgum F1 progeny have similar fitness with respect to leaf area, seed production, and biomass (Sahoo et al. 2010). This suggests that there would not be a significant barrier in the F1 generation to deter crop alleles from introgressing into shattercane populations. The objective of these experiments was to determine growth and fitness characteristics of the F2 progeny of the shattercane x sorghum hybridization and to evaluate overwinter survival of the seeds. Two experiments were conducted at the University of Nebraska South Central Agricultural Laboratory near Clay Center, NE, and the Havelock research station near Lincoln, NE. In the fall of 2011, 20 panicles were collected from a shattercane population in a corn field near Arapahoe, NE. A sample of these seeds was grown in the greenhouse and hand emasculated before flowering. These panicles were pollinated with commercial hybrid sorghum pollen. This produced 24 shattercane x sorghum F1 crosses. From each of these panicles several seeds were planted and allowed to mature to produce an F1 population. This F1 population was segregated from other sorghum and allowed to openly pollinate. Seeds from these F1 plants were collected to produce an F2 population. For the first experiment, 50 seeds from each of the F2 population, the sorghum parent, and the shattercane parent were sewn in the summer of 2012 and 2013 in

3.05 m rows. Emergence and plant height were tracked weekly and biomass and leaf area were measured at anthesis. Mature seeds from each panicle were also collected. The F2 generation did not appear to have the fitness advantages previously found in the F1 population. For the second experiment, 100 seeds from these same populations were sown in the field in the fall of 2012 in mesh baskets. The seeds from the shattercane had greater emergence than the F1 or the sorghum parent, suggesting that the overwintering survival is reduced in the F2 generation. This might result in decreased fitness compared to the shattercane parent.

WEED CONTROL IN SHELTERBELTS. Devin A. Wirth*, Richard K. Zollinger; North Dakota State University, Fargo, ND (86)

An experiment was conducted near Absaraka, ND to evaluate weed efficacy and soil residual of pre-emergent herbicides in shelterbelts. There were three replications of each treatment. Each replication was placed in a different shelterbelt with different species of trees. Tree rows were prepped for application by an application of glyphosate on August 22, 2012 followed by roto-tillage and an application of glyphosate on September 13, 2012. Treatments were applied October 26, 2012. Treatments applied were: indaziflam at 73 g/ha, indaziflam at 95 g ai/ha, indaziflam + rimsulfuron at 73 + 35 g/ha, oxyfluorfen + pendimethalin at 1120 + 2130 g/ha, dichlobenil + pendimethalin at 4500 + 2130 g/ha, simazine + pendimethalin at 3370 + 2130 g/ha. As snow cover melted in the spring the preemergent herbicides were activated. An evaluation was taken each month from June 2013 to October 2013. Treatment ratings varied by replication as a result of established grass border interference. Due to dry, compacted soils some treatments were not effectively roto-tilled. Treatments sprayed on bare ground gave near complete weed control the entire year. Oxyfluorfen + pendimethalin and the low rate of indaziflam applied alone gave 56%-68% grass control and 45%-66% broadleaf control. Simazine + pendimethalin gave 63% dandelion control and had no control on tree seedlings. The higher rate of indaziflam applied alone gave 69% dandelion control but 81%-99% control on all other weed species. Dichlobenil + pendimethalin and indaziflam + rimsulfuron gave 93%-99% weed control on all weed species. Indaziflam was comparable to dichlobenil + pendimethalin when tankmixed with rimsulfuron.

THE GREAT LAKES PHRAGMITES COLLABORATIVE: BUILDING A COMMUNICATION STATEGY TO INCREASE REGIONAL COLLABORATION ON INVASIVE SPECIES MANAGEMENT. Amanda Sweetman*[1], Spphie Taddeo[1], Heather Braun[1], Kurt P. Kowalski[2]; [1]Great Lakes Commission, Ann Arbor, MI, [2]USGS-Great Lakes Science Center, Ann Arbor, MI (87)

*NO ABSTRACT SUBMITTED*

INVASIVE PHRAGMITES IN GREAT LAKES COASTAL CORRIORS: COMBINING RADAR MAPPING AND HABITAT SUITABILITY MODELING IN AN ONLINE DECISION SUPPORT TOOL. Wesley A. Bickford*[1], Kurt P. Kowalski[1], Martha L. Carlson Mazur[2], Mike R. Eggleston[1]; [1]USGS-Great Lakes Science Center, Ann Arbor, MI, [2]Boston College, Chestnut Hill, ME (88)

*NO ABSTRACT SUBMITTED*

INVASIVE PLANT AND NATIVE AMPHIBIAN INTERACTIONS. Lisa Regula Meyer*; Kent State University, Kent, OH (89)

*NO ABSTRACT SUBMITTED*

IS THE SOLUTION WORSE THAN THE PROBLEM? EXAMINING THE EFFECTS OF *MYRIOPHYLLUM SPICATUM* AND TRICLOPYR ON *LITHOBATES PIPIENS* TADPOLES. Amanda Curtis*, M. Gabriela Bidart-Bouzat; Bowling Green State University, Bowling Green, OH (90)

*NO ABSTRACT SUBMITTED*

HISTORIC MINING AND AGRICULTURE AS INDICATORS OF PRESENCE AND DISTRIBUTION OF TWO WIDESPREAD INVASIVE PLANT SPECIES. Kellen M. Calinger*, Elisabeth Calhoon, Hsiao-chi Chang; Ohio State University, Columbus, OH (91)

Anthropogenic disturbances provide opportunities for the introduction of invasive species which are challenging and expensive to remove and often substantially alter local plant communities. Thus, clarifying the effects of various disturbances on non-native species invasion is crucial for managing these species. We assessed the relationship between incidence and abundance of two prominent invasive plant species (*Rosa multiflora* and *Berberis thunbergii*) and land-use history at the Powdermill Nature Reserve, a 900-ha deciduous forest in the eastern USA. Using data from an extensive vegetation survey collected between1939 and 2008, we evaluated the effects of historical land uses which included mined, logged, transitioned from agriculture to forest, developed to forest, always forest, and always developed. *Rosa multiflora* was significantly more likely to be found in plots with any historical disturbances relative to always forested plots, while presence of *B. thunbergii* was only significantly more likely in plots with a history of mining, logging, and agriculture. Greater proximity to roads increased the likelihood of presence of both species. *Rosa multiflora* was significantly more abundant in plots with mining and historic agriculture (37% and 35% increase in cover class, respectively) when compared to always forested plots. *Berberis thunbergii* was only significantly more abundant in plots with historic agriculture (35%) relative to always forested plots. Nearness to roads did not significantly affect the abundance of either species. Our results suggest that numerous historic and current disturbances (e.g. logging and roadways) can aid the introduction of invasive species into new habitats and ecosystems although only high-intensity disturbances such as mining and agriculture impact abundance of these species after their arrival.

THE EFFECT OF INVASIVE SPECIES ON GRASSLAND BIRD NESTING. Chelsea L. Merriman*, Kerri C. Martin; University of Notre Dame, South Bend, IN (92)

*NO ABSTRACT SUBMITTED*

DOES THE RARE, NATIVE WEST VIRGINIA WHITE BUTTERFLY (*PIERIS VIRGINIENSIS*) OVIPOSIT ON INVASIVE GARLIC MUSTARD (*ALLIARIA PETIOLATA*)? Samantha L. Davis*, Don Cipollini; Wright State University, Fairborn, OH (93)

*NO ABSTRACT SUBMITTED*

INVASIVE PLANT DYNAMICS IN ASH ECOSYSTEMS. Kathleen Knight*; USDA Forest Service, Delaware, OH (94)

*NO ABSTRACT SUBMITTED*

## NATIVE-INVASIVE TREE LITTER MIXTURES ENHANCE INVASIVE SPECIES' IMPACTS ON NUTRIENT CYCLING DURING THE GROWING SEASON.

Michael J. Schuster*, Jeffrey S. Dukes; Purdue University, West Lafayette, IN (95)

Some of the most aggressive invasive plant species are able to promote their success through positive plant-soil feedbacks. One way they can do this is by producing high quality (low C:N) leaf litter, which can accelerate decomposition and enhance system nutrient availability. However, when leaf litters of differing quality decompose in a common environment, they can exhibit non-additive effects (NAE) on decomposition and N loss where the rate of decomposition differs from what would be expected based on each component litter independently. We hypothesized that litter mixtures containing invasive and native tree litter would experience synergistic NAE. To test this, we conducted a litter bag experiment using two-species litter mixtures from four invasive tree or shrub species (*Acer ginnala*, *Elaeagnus umbellata, Lonicera maackii,* and *Morus alba*) and four native tree species (*Carya glabra, Cercis canadensis, Liriodendron tulipifera,* and *Quercus palustris*) commonly found in Indiana, USA. To examine possible effects of evenness, bags containing mixed-species litter were filled at loading ratios of 10, 50, or 90 percent invasive species litter. Litter bags were collected after 90 or 365 days, and were measured for mass loss and nitrogen loss. We detected NAE on mass loss in all species pairings, although not at every loading ratio and the presence, sign, and strength of observed NAE varied over time. NAE on N loss were more frequently detected than NAE on mass loss, and were almost always antagonistic after 90 days and synergistic after 365 days of decomposition. The strength and sign of NAE were significantly correlated with relative differences between native and invasive species litter chemistry, where higher quality invasive species litter promoted stronger antagonistic NAE in both mass loss and N loss at 90 days, and stronger synergistic NAE at 365 days. Effects of tissue chemistry were strongest in mixtures containing a majority of invasive species litter after 365 days of decomposition. The NAE on N loss we observed suggest that invasive species frequently stimulated increased N release from mixed litter during the growing season. Invasive plants with relatively nutrient-rich litter may therefore facilitate more positive plant-soil feedbacks than would be expected by enhancing N release from litter mixtures and promoting temporal synchrony between N availability and demand.

## EXPLORING DIRECT AND INDIRECT COMPARATIVE ALLELOPATHIC EFFECTS OF INVASIVE *LONICERA JAPONICA* AND NATIVE *LONICERA SEMPERVIRENS*.

Nate Godby*, Kendra Cipollini; Wilmington College, Wilmington, OH (96)

Invasive plants may impact native species through novel weapons, such as allelochemicals, either directly or indirectly. We tested the Novel Weapons Hypothesis by examining if invasive *Lonicera japonica* (Japanese honeysuckle) represents a greater allelopathic threat than a native vine, *Lonicera sempervirens* (trumpet honeysuckle), to a native grass species, *Elymus hystrix* (bottlebrush grass). We compared the effects of leaf extracts of invasive *L. japonica* and native *L. sempervirens* on the performance of *E. hystrix* in sterilized and unsterilized soils, using varying concentrations of extract treatments. We also determined the effects of leaf extracts of varying concentrations of *L. japonica* and *L. sempervirens* on germination of *E. hystrix.* Native *L. sempervirens* exhibited greater effects than *L. japonica* on percent germination of *E. hystrix*, with greater effects at increasing concentrations of both extracts overall. For growth, as measured by total biomass, plants grown with extracts of *L. japonica* were larger compared to plants grown with extracts of *L. sempervirens*. Plants growing in sterilized soil were significantly larger and had a smaller root to shoot ratio compared to plants growing in unsterilized soil. There was a significant interaction between species extract and soil sterilization. Plants grown with extracts of *L. japonica* were similar in biomass between the two sterilization treatments, while plants grown with extracts of *L. sempervirens* decreased from the sterilized to the unsterilized treatments. Our experiments therefore are not consistent with the Novel Weapons Hypothesis for *L. japonica* leaf extract allelopathy and show evidence of direct and indirect effects of leaf extracts of *L. sempervirens* on germination and growth of *E. hystrix.*

CURRENT ISSUES AND FUTURE PERSPECTIVE: UPDATE FROM CAST. Phillip W. Stahlman*; Kansas State University, Hays, KS (97)

With each passing generation, fewer people are directly or indirectly involved with agriculture, resulting in an increasingly high percentage of the population that is either uninformed or misinformed about modern agricultural science and technology as well as food safety. The situation today is not much different than it was more than 40 years ago when public concern over some aspects of agriculture highlighted the need for a reputable source of accurate information on agricultural science and technology. As a result of a meeting convened by the National Research Council of the National Academy of Sciences and attended by visionary leaders of 16 agriculture-related scientific societies, the Council for Agricultural Science and Technology (CAST) was founded in 1972 with a mission "*to assemble, interpret, and communicate credible science-based information regionally, nationally, and internationally to legislators, regulators, policymakers, the media, the private sector, and the general public."* CAST is a nonprofit organization composed of scientific societies and many individual, student, company, nonprofit and trade group, and associate society members. The organization is funded through membership dues, unrestricted financial gifts, and occasional grants. Throughout its nearly 42-year history, CAST has fulfilled its mission by publishing factual, science-based reports on important topics related to agriculture, food sciences, and environmental issues written and reviewed by reputable subject-matter experts. They do this without financial compensation; uphold the principles of scholarship by balancing logic, facts, and truths from competing hypotheses and experimental results; and set aside personal emotions and politics to allow unbiased analysis and interpretation of science. As a result, CAST has earned a strong reputation among regulators and policymakers and is viewed as a highly respected source of science-based information. The CAST brand, however, is not as well known or valued as it should be among the general public or, sadly, among many early and mid-career agriculture-related scientists. CAST has expanded the use of video and social media, and it continues to seek ways to increase connectivity with broader and younger audiences.  Funding issues, competing with the vast amount of information [misinformation] available on the Internet, and the ability to access that information via cell phones and other mobile devices are major challenges. Yet the need for credible science-based information is no less today than in the past and will only increase in the future. CAST has several publications in various stages of progress on important issues of agricultural and societal interests. A few examples of forthcoming publications of particular interest to NCWSS members include *The Contributions of Pesticides to Pest Management in Meeting the Global Need for Food Production by 2050; The Potential Impacts of Mandatory Labeling for Genetically Engineered Food; Recruiting and Educating Graduate Students to Become Researchers and Leaders in Global Agricultural Studies*; and a series of papers on *The Need for Agricultural Innovation to Sustainably Feed the World by 2050.* Your membership is needed to help CAST fulfill its mission of educating an increasingly uninformed or misinformed public about agricultural science and technology.

WSSA EPA-SUBJECT MATTER EXPERT POSITION: MY INITIAL IMPRESSIONS. Michael Barrett*; University of Kentucky, Lexington, KY (98)

*NO ABSTRACT SUBMITTED*

NCWSS PRESIDENTIAL ADDRESS. Dave Johnson*; DuPont Pioneer, Johnston, IA (99)

*NO ABSTRACT SUBMITTED*

NECROLOGY REPORT. Kirk A. Howatt*; North Dakota State University, Fargo, ND (100)

*NO ABSTRACT SUBMITTED*

INCREASED SOYBEAN SEEDING RATES VERSUS PREEMERGENCE HERBICIDE USE. Ryan P. DeWerff*, Vince M. Davis, Shawn P. Conley; University of Wisconsin-Madison, Madison, WI (101)

Since the introduction of glyphosate-resistant (GR) soybean varieties in 1996, seed costs have increased by \$100 ha$^{-1}$ (USDA-ERS, 2012). This rise in seed cost has generated interest in reducing seeding rates to increase economic return. However, reduced seeding rates can slow canopy development which may have an adverse effect on weed suppression. In order to realize the best economic seeding rate, weed management may be more dependent on residual herbicides for adequate control. Field studies were conducted in 2012 and 2013 at the University of Wisconsin Arlington Research Station to establish the effectiveness of weed suppression by increased seeding rates in relation to residual herbicide control. Plots were planted in mid-May in 38-cm rows at five seeding rates: 469,300 (high), 296,400 (moderate), 469,300 (high blend), 234,650 (low blend), and 148,200 (low) seeds ha$^{-1}$. High blend and low blend treatments consisted of 172,900 and 86,450 glyphosate susceptible seeds ha$^{-1}$, respectively. A preemergence (PRE) herbicide was applied to half of the plots within three days of planting. Two different postemergence (POST) herbicide programs were applied at the V4 soybean growth stage. One of the programs contained glyphosate, while the other consisted of conventional (non-glyphosate) herbicides. Soybean canopy coverage was estimated weekly using a digital imagery technique. Weeds were counted, measured for height, and destructively subsampled for biomass accumulation prior to the V4 POST application and prior to harvest. Higher soybean populations suppressed early season weed growth in 2012 when a PRE residual herbicide was not used. Weed dry weight at the POST timing decreased linearly at a rate of 0.53 g m$^{-2}$ for each additional increase of 1000 soybean plants. There was no response to an increase in soybean population in 2013. The PRE residual herbicide used in our experiment significantly reduced weed dry weights and weed densities prior to the POST application in both years ($P<0.0001$). Weed dry weights were reduced from 71.2 g m$^{-2}$ to 4.1 g m$^{-2}$ and weed densities decreased from 188 plants m$^{-2}$ to 13 plants m$^{-2}$ when a residual herbicide was applied. The seeding rate required to maximize soybean yield was influenced by the PRE herbicide in 2012 ($P<0.0001$). When a PRE herbicide was applied, there was no significant difference in yield between the high, moderate, and low seeding rates. However, in the absence of a PRE, yield was different for each level ($P<0.0001$), and the high, moderate, and low seeding rates produced 3748, 3261, and 2292 kg ha$^{-1}$, respectively. Thus, the use of a residual herbicide enabled a seeding rate as low as 148,200 seeds ha$^{-1}$ to achieve a yield statistically similar to a seeding rate of 469,300 seeds ha$^{-1}$. Additionally, the use of the residual herbicide reduced the number and size of weeds exposed to the POST herbicide application which is an important element of herbicide resistance management.

EFFECT OF SOYBEAN PRE- AND POST-EMERGENCE HERBICIDES ON GLYPHOSATE, GLUFOSINATE, AND IMIDAZOLINONE RESISTANT VOLUNTEER CORN. Parminder S. Chahal*[1], Greg R. Kruger[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (102)

Volunteer corn (*Zea mays*) is a problematic weed in soybeans grown in rotation with corn and continuous corn cropping systems. Graminicides have been used commonly for control of volunteer corn in soybean. However, there is a lack of scientific information on the response of glufosinate-, glyphosate-, and imidazolinone-resistant volunteer corn to preemergence (PRE) and postemergence (POST) herbicides registered for grass weed control in soybeans. Experiments were conducted under greenhouse conditions to evaluate the response of herbicide resistant corn volunteers to 20 PRE- and 17 POST herbicides. In POST study, corn volunteers at two growth stages (12.5-15 cm and 30.5-33 cm tall) were treated with herbicides. Control of volunteer corn was varied by POST herbicides and growth stage. All the ACCase inhibitor herbicides provided > 90% control to all herbicide-resistant volunteer corn regardless of the growth stage of volunteer corn. Herbicides including imazamox, imazaquin, acifluorfen, and chlorimuron tank mixed with glyphosate provided > 90% control of glufosinate- and imidazolinone-resistant volunteer corn. The majority of the PRE herbicides did not affect the cumulative emergence of volunteer corn at 21 DAT and < 50% injury to all three herbicides resistant volunteer corn plants except clomazone and indaziflam at all the rates reduced emergence < 8 plants pot$^{-1}$ and usually resulted in injury > 90%. The result of this study indicates that glufosinate-, glyphosate-, and imidazolinone-resistant volunteer corn can be adequately controlled with few POST herbicides registered in soybeans; however, except clomazone, PRE herbicides did not provide acceptable control of volunteer corn.

## CONTROL OF GLYPHOSATE-RESISTANT GIANT RAGWEED IN GLUFOSINATE- RESISTANT SOYBEAN.

Simranpreet Kaur*, Lowell Sandell, Rodrigo Werle, Amit J. Jhala; University of Nebraska-Lincoln, Lincoln, NE (103)

Glyphosate- resistant giant ragweed (*Ambrosia trifida* L.) is a troublesome weed of Mid- western United States causing yield loss to a great extent in corn and soybeans. Its early and extended emergence along with rapid growth habit makes giant ragweed a competitive weed in several agronomic crops. Therefore, early spring control of giant ragweed is necessary. Glufosinate is an alternate POST-applied herbicide for control of glyphosate-resistant giant ragweed. The objective of this study was to evaluate efficacy of several burndown herbicides followed by glufosinate for control of glyphosate-resistant giant ragweed in glufosinate-resistant soybean. Several burndown treatments that included 2,4-D, flumioxazin, glufosinate, paraquat, saflufenacil and sulfentrazone provided 79 to 99% control of giant ragweed at 21 days after burndown treatment. These treatments were followed by early- and late-POST application of glufosinate and usually resulted in 76-99% giant ragweed control at harvest. Although comparable with several other treatments, burndown application of 2,4-D or 2,4-D plus saflufenacil followed by early- and late-POST application of glufosinate resulted in 3,378 and 3,079 kg ha$^{-1}$ soybean yield. Minimum emergence of glyphosate-resistant giant ragweed (<2 plants m$^{-2}$) was observed in plots treated with tank mixtures of saflufenacil and 2,4-D applied alone or in tank mix and followed by glufosinate.

## CONTROL OF GLYPHOSATE-RESISTANT GIANT RAGWEED IN GLYPHOSATE-TOLERANT NOTILL SOYBEANS.

Lowell Sandell*[1], Greg R. Kruger[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (104)

Giant ragweed (*Ambrosia trifida*) is an early spring germinating summer annual broadleaf weed that is of increasing importance in corn, soybean, pasture, and non-crop areas of Nebraska. Glyphosate-resistant populations have been identified in multiple eastern Nebraska counties. These populations pose a significant management challenge in no-till soybean production. Field experiments were established at a glyphosate-resistant giant ragweed site near David City, NE in 2012 and 2013 to evaluate different herbicide management approaches in no-till soybeans. The treatments were intended to compare burndown applications with and without 2,4-D followed by preemergence or post emergence management approaches. The study was a complete randomized block design, replicated four times. Data analysis was conducted in SAS with PROC MIXED. Visual weed control was recorded at 7, 14 and 21 days after burndown applications and 7, 30 and 120 days after the final post emergence applications. Soybean yield and giant ragweed density were collected at the conclusion of the study. The results suggest that burndown treatments that included 2.4-D followed by an at-plant residual herbicide application resulted in the greatest giant ragweed control and soybean yield. A diversified management approach that includes 2,4-D as a component of a burndown application is necessary to achieve acceptable giant ragweed control and maintain soybean yield potential in fields with glyphosate-resistant giant ragweed.

## INFLUENCE OF SOYBEAN SEEDING RATE, ROW SPACING AND HERBICIDE PROGRAMS ON THE CONTROL OF RESISTANT WATERHEMP IN GLUFOSINATE-RESISTANT SOYBEAN.

John Schultz*, Eric B. Riley, Jimmy D. Wait, Kevin W. Bradley; University of Missouri, Columbia, MO (105)

Field trials were conducted in 2012 and 2013 near Moberly, Missouri to determine the effects of seeding rate, row spacing, and herbicide programs on the control of glyphosate-, ALS-, and PPO-resistant waterhemp (*Amaranthus rudis* Sauer) in glufosinate-resistant soybean. Soybeans were planted in 19, 38, and 76-cm rows at a density of 185,000, 284,000, 383,000 and 482,000 seeds per hectare. The two herbicide programs evaluated included a preemergence (PRE) application of 0.27 kg/Ha fomesafen plus 1.22 kg/Ha *S*-metolachlor followed by a postemergence (POST) application of 0.60 kg/Ha glufosinate plus 1.26 kg/ha acetochlor (PRE fb POST w/RES program) compared to two POST applications of 0.60 kg/Ha glufosinate (2-pass POST program). All POST applications were made once waterhemp reached 10-cm in height. When averaged across all herbicide treatments and planting populations, soybean spaced 19-cm apart reduced late-season waterhemp density 30% more than 76-cm rows. However, there were no differences in late-season waterhemp density as a result of soybean seeding rate. Across all row spacings and planting populations, the 2-pass POST glufosinate program reduced late-season resistant waterhemp density by 74% while the PRE fb POST w/ RES program reduced resistant waterhemp density by 99% compared to the non-treated control. Soybean yield was greater in response to the PRE fb POST w/ RES program (1916 kg/ha) than the 2-pass POST program (1814 kg/ha). Seeding rates greater than 284,000 seed per hectare yielded higher than 185,000 seeds per hectare. Overall, results from these experiments indicate that PRE fb POST w/RES herbicide programs and narrow row spacings provide greater control of GR waterhemp than two-pass POST programs and wide row spacing in glufosinate-resistant soybean when planted at seeding rates of 284,000 seeds per hectare or greater.

## MULTIPLE-RESISTANT PALMER AMARANTH CONTROL WITH SOIL-APPLIED HERBICIDES IN MICHIGAN.
David Powell*, Christy L. Sprague; Michigan State University, East Lansing, MI (106)

Field studies were conducted in 2011, 2012 and 2013 to determine effective soil-applied herbicides for control of glyphosate/ALS-resistant Palmer amaranth in Michigan. All three years, flumioxazin (90 g ha$^{-1}$) was amongst the best treatments for Palmer amaranth control. Control 28 DAT was 85, 64, and 99% in 2011, 2012, and 2013, respectively. A lower rate of flumioxazin (70 g ha$^{-1}$) was also applied in 2012 and 2013 and Palmer amaranth control was similar to the higher flumioxazin rate. Flumioxazin combinations, especially with pyroxasulfone also provided good Palmer amaranth control. Sulfentrazone provided similar Palmer amaranth control to flumioxazin in two of the three years. Differences between years, may be attributed to a lower rate of sulfentrazone (210 g ha$^{-1}$) applied in 2011 compared with 2012 and 2013 (280 g ha$^{-1}$) or possible differences in precipitation. To determine if these differences were due to precipitation, a subsequent greenhouse experiment was conducted evaluating the effect of simulated rainfall on control of glyphosate/ALS-resistant Palmer amaranth with flumioxazin and sulfentrazone. Twenty-five seeds of glyphosate/ALS-resistant Palmer amaranth were planted in pots containing a Capac loam soil. Immediately after planting, flumioxazin at 22, 45, and 90 g ha$^{-1}$ and sulfentrazone at 70, 140, and 280 g ha$^{-1}$ were applied to the soil surface, representing 0.25, 0.5 and 1X of the field use rates for the two herbicides. Two hours after herbicide application, pots were watered to simulate rainfall events of 0, 0.16, 0.32, 0.64, 1.3, 2.5, and 5 cm ha$^{-1}$. All pots were sub-irrigated to maintain a water level of 20% w/w. Palmer amaranth emergence was greatest in the absence of simulated rainfall for both herbicides with emergence counts ranging from 31 to 85% of the untreated control, depending on herbicide rate. A minimum of 0.33 cm of simulated rainfall was needed for the greatest reductions in Palmer amaranth emergence. However, at the lower sulfentrazone rates (0.25 and 0.5X) rainfall amounts of 5 cm resulted in greater Palmer amaranth emergence, suggesting that sulfentrazone may be leached below the Palmer amaranth emergence zone. This response was not observed at the highest sulfentrazone rate (280 g ha$^{-1}$) or with any rate of flumioxazin. This suggests that rainfall amounts and sulfentrazone rate may have a major effect on Palmer amaranth control and may help explain differences between flumioxazin and sulfentrazone in our field studies. For early-season control of glyphosate/ALS-resistant Palmer amaranth flumioxazin should be applied at a minimum of 70 g ha$^{-1}$ and sulfentrazone should be applied at a minimum of 280 g ha$^{-1}$ to mitigate the effects of rainfall. However, even with this early-season control, subsequent postemergence herbicide applications will still be necessary to provide season-long control of glyphosate/ALS-resistant Palmer amaranth in soybean.

## EFFECT OF HERBICIDE AND APPLICATION TIMING ON RESIDUAL CONTROL OF HORSEWEED RESISTANT TO GLYPHOSATE AND ALS INHIBITORS.
Bryan Reeb*, Mark M. Loux; The Ohio State University, Columbus, OH (107)

Two field studies were conducted in west central Ohio to determine the effective strategies for management of spring-applied residual herbicides for control of glyphosate-resistant horseweed (*Conyza Canadensis*) in no-tillage glyphosate-resistant soybeans. The use of ALS-inhibiting herbicides was deemphasized in these studies due to the prevalence of horseweed populations that are resistant to both glyphosate and ALS-inhibiting herbicides. The objective of the first study, conducted in 2012 and 2013, was to determine the effect of application timing and rate on the residual control of horseweed from metribuzin, flumioxazin, and sulfentrazone. Herbicide was applied 30 days prior to soybean planting (early April), 7 days prior to planting (late April), or as a split application – early April followed by at planting. The study received a postemergence application of glyphosate approximately 5 weeks after planting. Measurements included visual observations of horseweed control and enumeration of horseweed population density, at soybean planting, at postemergence application, and just prior to soybean harvest for each study. Over the two years of this study, control just prior to harvest exceeded 85% only for three metribuzin-containing treatments: 30 day preplant application of glyphosate, 2,4-D and metribuzin (630 g ai/ha); 7 day preplant application of glyphosate, 2,4-D and metribuzin (630 g ai/ha); and a split application of glyphosate, 2,4-D and metribuzin (210 g ai/ha) at 30 days preplant followed by an at-plant application of glufosinate and metribuzin (310 g ai/ha). The low population density counts for these treatments reflected the control ratings, ranging from 0 to 0.83 plants $m^{-2}$. End-of-season control did not exceed 80 and 66% for flumioxazin and sulfentrazone treatments in 2012 and 2013, respectively, regardless of application timing. The objective of the second study, conducted in 2013, was to determine the optimum combination of non-ALS-inhibiting herbicides to maximize residual control of horseweed when applied in early spring. Various combinations and rates of metribuzin, flumioxazin, saflufenacil, dicamba, and sulfentrazone were applied 30 days prior to planting. Treatments were applied with glyphosate and 2,4-D (2,4-D was omitted from dicamba-containing treatments). Control at the time of soybean planting ranged from 83 to 100% for a number of treatments consisting of combinations of saflufenacil, flumioxazin, sulfentrazone, and/or metribuzin. Control just prior to soybean harvest exceeded 85% only for three saflufenacil-containing combinations: flumioxazin (90 g ai/ha), metribuzin (530 g ai/ha) plus saflufenacil (40 g ai/ha); flumioxazin (90 g ai/ha) plus saflufenacil (40 g ai/ha); and sulfentrazone (200 g ai/ha) plus saflufenacil (40 g ai/ha). Effectiveness of these treatments was reflected by the population densities, which ranged from from 0.50 to 0.67 plants $m^{-2}$. Control just prior to soybean harvest did not exceed 77 or 33% for flumioxazin or dicamba applied alone, respectively, and was not improved by mixing these two herbicides. The second study will be repeated in 2014.

## SOYBEAN BREEDING OVER THE LAST 80+ YEARS HAS IMPROVED PLANT BRANCHING AND REDUCED THE PENALTY FOR LOW SEEDING RATES. Vince M. Davis*[1], Justin Suhre[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Illinois, Urbana-Champaign, IL (108)

Yield potential of soybean has increased during the past century; however, there is little understanding about the plant characteristics that have contributed most to yield gain. Studies to determine how genetic gain of soybean yield is influenced by seeding rate were conducted under the premise that newer cultivars would express higher yield than older cultivars when grown in higher plant densities. To evaluate this, 116 soybean cultivars equally representing maturity group II and III cultivars released over the last 80 years were evaluated at high and low seeding rates in Wisconsin, Minnesota, Illinois, and Indiana. Seeding rates were 445,000 seeds/ha (high) and 148,000 seeds/ha (low). Seed yield was greater for the high seeding rate versus low seeding rate throughout all cultivars and years of release, but the difference was larger in newer cultivars. Harvest index equally improved over time for both seeding rates. The differences observed primarily came from increased pods and seeds $plant^{-1}$. Most interestingly, newer cultivars provided greater yields than older cultivars in higher seeding rates, however, newer cultivars grown in low seeding rates increased yield linearly by $0.118 (\pm 0.02)x - 208.0$ grams $plant^{-1}$, which was three times greater than at the high seeding rate. We elucidated this greater yield trend came from seeds produced on plant branches. Therefore, newer cultivars produce more compensatory yield on plant branches under lower plant populations than older cultivars, so over the last 80 years there has been a diminishing response to expected yield changes in relationship to plant density.

## HARVEST AID EFFECTS ON BLACK BEAN DESICCATION AND YIELD. Amanda M. Goffnett*, Christy L. Sprague; Michigan State University, East Lansing, MI (109)

The use of preharvest herbicides to assist with desiccation of black beans is a common harvest practice used by Michigan growers to achieve uniform maturity. Herbicide choice and application timing can effect the desiccation and yield of black beans. Field trials were conducted at the Saginaw Valley Research and Extension Center near Richville, MI in 2013 to evaluate the effects of preharvest herbicide applications on black bean desiccation and yield at two application timings. Type II black bean varieties: ‘Zorro’, ‘Eclipse’, and ‘B10244’ were planted at two different dates, June 13 and June 26, for diverse growing conditions. Three desiccation treatments: 1) paraquat (0.56 kg $ha^{-1}$) + non-ionic surfactant (0.25% v/v), 2) glyphosate (0.84 kg a.e. $ha^{-1}$) + ammonium sulfate (2% w/w), 3) saflufenacil (0.05 kg $ha^{-1}$) + methylated seed oil (1% v/v) + ammonium sulfate (2% w/w) were compared to an untreated control for each variety. Desiccation treatments were applied at two different timings for each planting date: a) 50% of pods were yellow (early) and b) 80% of pods were yellow (normal). The early timing was to evaluate differences in desiccation treatments and many times there are areas in a field that may be at this stage when a desiccation treatment is made. Black bean desiccation was assessed at 3, 7, and 14 days after treatment (DAT) and yield direct harvested. Differences in black bean desiccation between herbicides were greatest at the early application timing for both planting dates. At 3 DAT, desiccation was greatest with paraquat for the early planting and with saflufenacil for the later planting. For the later application timing, black bean desiccation was similar for all herbicide treatments, except with ‘Zorro’ where glyphosate was lower at both planting dates and paraquat was lower at the later planting date than saflufenacil. By 7 DAT, black bean desiccation was over 95% for both application timings for the early planting and for the later planting. Differences in yield were mostly attributed to variety and planting date. Yield was only reduced by desiccation treatment for the earlier planted beans when saflufenacil was applied early to ‘Zorro’ and ‘B10244’ or when paraquat was applied early to ‘B01244’. The quick desiccation of these treatments stopped continued development of these beans. Overall desiccation was effective by all herbicide treatments. The speed of desiccation and effect on overall yield were affected by application timing and planting date.

## EFFECT OF TILLAGE AND HERBICIDES ON CONTROL OF GLYPHOSATE-RESISTANT GIANT RAGWEED IN CORN AND SOYBEANS. Zahoor A. Ganie*, Lowell Sandell, Amit J. Jhala; University of Nebraska-Lincoln, Lincoln, NE (110)

Glyphosate-resistant giant ragweed (*Ambrosia trifida*) is one of the competitive and difficult to control weeds in corn and soybeans. Giant ragweed has an early and extended germination period and a rapid growth rate that has made management very difficult with single application of PRE or POST herbicide treatments, and/or multiple applications of herbicides with the same mode of action. The objective of this study was to evaluate the control of glyphosate-resistant giant ragweed with an integrated approach combining tillage and herbicides. Two experiments were conducted in 2013 for control of glyphosate-resistant giant ragweed in corn near Clay Centre, NE and in soybean at David City, NE. The results from corn trial reflected that giant ragweed density and biomass was lower with spring disk followed by *(fb)* herbicides compared with herbicides applied alone; however, giant ragweed control was same (>90%) under both situations except non-treated control and E-Post application of 2,4-D alone. In soybean trial, giant ragweed control (> 95%) and yield (2,895 kg ha$^{-1}$) was significantly higher with spring disk *fb* herbicides. In addition, burndown application of 2,4-D *fb* herbicides resulted in > 90% giant ragweed control and 3,322 kg ha$^{-1}$ soybean yield compared to only POST herbicides. It was observed in both the trials that giant ragweed density and control was higher in treatments with spring disk or PRE burn-down application (in case of soybeans) compared to only POST herbicide application. The overall results show that inclusion of tillage with herbicides improves management of glyphosate-resistant giant-ragweed.

## MANAGEMENT OF PALMER AMARANTH IN CORN USING COVER CROPS AND HERBICIDES. Matthew S. Wiggins*, Lawrence E. Steckel; University of Tennessee, Jackson, TN (111)

Palmer amaranth (*Amaranthus palmeri* S. Wats) continues to be the driver weed affecting weed management decisions in Tennessee. This dioecious summer-annual weed has been documented to reduce yield of agronomic crops if adequate control is not attained. Current difficulties in controlling Palmer amaranth include its biological characteristics and herbicide resistance. Palmer amaranth has a lengthy germination window, a robust growth habit, the ability to produce of large quantities of viable seed and is resistant to many classes of herbicides, including glyphosate and acetolactate synthase (ALS)-inhibiting herbicides. Successful management schemes for controlling Palmer amaranth include the use of PRE-emergence (PRE) herbicides, overlaying residual chemistries, making timely applications of POST-emergence (POST) herbicide and integrating cultural control methods. Unfortunately, rainfall to activate PRE’s and residual herbicides can be sporadic at best in Tennessee. Therefore, timely applications of POST herbicides are essential for many producers to grow a profitable crop. However, this heavy reliance on POST herbicide applications increases selection pressure and the possibility of herbicide resistance. Integrating cultural control methods, such as cover crops, is a viable option available for area producers to reduce selection pressure and gain early season weed control. This renewed interest in cover crops calls for a better understanding of herbicide and cover crop integration to allow producers to make effective weed management decisions. A study was conducted during the 2013 growing season to investigate Palmer amaranth control in a corn system where treatments of cover crops and POST herbicides applications were applied. The cover crops evaluated were crimson clover (*Trifolium incarnatum* L.) and hairy vetch (*Vicia vilosa* L.). Seeding rates were 16.8 kg hectare$^{-1}$ and 23.6 kg hectare$^{-1}$ of viable seed for crimson clover and hairy vetch, respectively. Cover crops were established in the autumn of the previous year using a no-till drill and were terminated approximately three weeks prior to estimated corn planting date. Prior to chemical termination of cover crops, biomass yields were obtained by clipping a 0.1 m$^2$ quadrat above the ground. The POST herbicide applications were applied when Palmer amaranth reached a height of 15-20 cm, which was approximately 40 days after corn planting date. Herbicide treatments included glyphosate + s-metolachlor + mesotrione (1048 + 1048 + 105 g ha$^{-1}$), thiencarbazone-methyl + tembotrione (15 + 75 g ha$^{-1}$), and glyphosate (1532 g ae ha$^{-1}$). All herbicide applications were tanked mixed with atrazine (1671 g ha$^{-1}$). Palmer amaranth control was assessed starting 14 days before application (DBA) and continued until 21 days after application (DAA). Weed density, corn plant height, and yield data were also assessed in this trial. Experimental design was a randomized complete block design with four replications and a factorial arrangement of treatments. Factors evaluated were cover crop specie and herbicide treatment. Means were separated using Fisher's Protected LSD at $P \leq 0.05$. Results indicate that early season weed suppression was achieved by using crimson clover and hairy vetch at the 14 DBA, 7 DBA, and 7 DAA evaluation timings. Corn plant height was increased when grown in plots with a legume cover crop, suggesting that the corn crop benefited from the additional nitrogen provided by the legume cover crops. However, the presence of a cover crop had no effect corn yield or weed density. Palmer amaranth control was increased at 7, 14, and 21 DAA by utilizing POST herbicide treatments. Subsequently, plots receiving a POST herbicide application had a lower weed density than plots that receiving no herbicide. In summary, these results indicate that using a high reside cover crop can offer some benefits in a corn system, including effective early season weed control of Palmer amaranth. However, timely applications of POST herbicides are essential for the season long control of this prolific pest.

WATERHEMP AND PALMER AMARANTH CONTROL USING DICAMBA, 2,4-D AND ISOXAFLUTOLE BASED CHEMICAL PROGRAMS. Strahinja Stepanovic*[1], Lawrence E. Steckel[2], Jason K. Norsworthy[3], Bryan G. Young[4], Kevin W. Bradley[5], William G. Johnson[6], Mark M. Loux[7], Vince M. Davis[8], Thomas W. Eubank[9], Lowell Sandell[1], Greg R. Kruger[10]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Tennessee, Jackson, TN, [3]University of Arkansas, Fayetteville, AR, [4]Southern Illinois University, Carbondale, IL, [5]University of Missouri, Columbia, MO, [6]Purdue University, West Lafayette, IN, [7]The Ohio State University, Columbus, OH, [8]University of Wisconsin-Madison, Madison, WI, [9]Mississippi State University, Stoneville, MS, [10]University of Nebraska-Lincoln, North Platte, NE (112)

*NO ABSTRACT SUBMITTED*

KOCHIA SEED CHARACTERISTICS UNDER DIFFERENT CROP CANOPIES. Andrew Esser*, Anita Dille; Kansas State University, Manhattan, KS (113)

A better understanding of kochia (*Kochia scoparia*) seed dynamics is necessary for long term management of this increasingly troublesome weed. The maternal environment in which a plant grows can affect seed viability, germination, and dormancy. The objective of this research was to evaluate maternal environmental effects on kochia seed production and document its variability in dormancy and viability of seed produced within a single kochia plant. A greenhouse experiment was conducted in spring of 2012 with two kochia seed populations from Hays, KS. Cropland and non-cropland populations were grown in the greenhouse with 12:12 h d/n at 27:21 C and limited to self-pollination. A field experiment was conducted during the summer of 2012 at the Kansas State Agricultural Research Center in Hays, KS. Kochia seeds from the cropland and non-cropland populations were planted with and without five different crop canopies, in a split plot RCBD, to mimic a typical environment in which kochia is found in the Great Plains of North America. Different canopies included corn, soybean, grain sorghum, wheat stubble, and kochia plants. For both greenhouse and field experiments initial flowering date was recorded and plant heights were taken for mature plants, then harvested and divided into three equal parts (top, middle, and bottom). Seeds were harvested from each section and a germination assessment was conducted with 50 seeds per plant section per petri dish with 10 mL water. Germinations were assessed for seed harvested directly off the plant or after a cold treatment where seeds were placed in a -4 C freezer for six weeks to simulate overwintering. Petri dishes were placed in a growth chamber with 12:12 h d/n at 20:10 C and germination counts were taken up to six weeks. Final germination percentages of seed from the greenhouse were different between the two biotypes with non-cropland being greater than cropland. Also, seed from the bottom third of the plant had greater total germination than the top of the plant. We speculate this is due to greater plant biomass for lower portions of the plant. We observed decreasing total germination with delay of flowering in the greenhouse grown plants. For the field study seed placement on the plant was not significant for germination of either off-plant or cold treatments. Final germination percentages ranged between 72 and 100% and there are interactions with presence and absence of crop canopy and kochia biotype on percent germination. Seed production was taken for the plants harvested from the field experiment on a 100 seed count weight by total weight basis. The only difference in seed production was less with weedy canopy compared to all other canopies. There was a maternal environmental effect on kochia seed characteristics with implications on future seedbank life.

INFLUENCE OF EMERGENCE TIMING ON THE VEGETATIVE AND REPRODUCTIVE DEVELOPMENT OF PALMER AMARANTH IN INDIANA. Doug J. Spaunhorst*, William G. Johnson; Purdue University, West Lafayette, IN (114)

Palmer amaranth populations from Arkansas, Indiana, Mississippi, Missouri, and Nebraska were established in a common garden experiment at Throckmorton Purdue Agricultural Center in Lafayette, Indiana. The purpose of this study was to evaluate the influence of planting date on Palmer amaranth (*Amaranthus palmeri*) emergence. Secondarily, this study analyzed the influence of planting date on plant growth and time of flowering. Approximately 900 Palmer amaranth seeds from each respective population were planted in each plot in three rows spaced 40 cm apart, and spanned a length of 9.1 m. Palmer amaranth planting occurred on May 21st (early June emergence), June 1st (mid-June emergence), and July 15th (late July emergence). Results from this study suggest Palmer amaranth populations from Missouri and Mississippi grow the tallest in Indiana compared to other populations when emergence occurred from early to mid-June. The Arkansas population grew slower compared to all other populations at two of the three planting dates. When planted on June 1st, the Arkansas population was similar in height to only the Indiana population at the end of the season, and was shorter than all other populations. Results from the July 15th planting date suggest Palmer amaranth from Nebraska grew faster compared to all other populations in response to moisture limiting conditions. Regardless of planting date, flowering data revealed that Palmer amaranth from Nebraska flowers rapidly and nearly all at once. In most instances the May 21st and June 1st planting dates resulted in similar trends with respect to percent flowering. The Indiana and Mississippi population flowered earlier and followed a similar trend in flowering, while populations from Missouri and Arkansas flowered at a slower pace and were similar with regard to the May 21st and June 1st planting dates. When Palmer amaranth planting was delayed until July 15th, nearly all plants from the Nebraska population flowered by the end of the season when precipitation was most limiting, however the Missouri and Indiana populations and Mississippi and Arkansas populations flowered less than 55 and 32%, respectively. This study indicates that Palmer amaranth from Nebraska is highly competitive and if established in Indiana will be difficult to manage. In addition, the Nebraska population appeared to respond to water limited conditions by flowering all at once. Palmer amaranth from Arkansas appears to be less competitive and flower later than other populations.

INFLUENCE OF SPRING TILLAGE ON EMERGENCE OF GIANT RAGWEED IN NEBRASKA. Rodrigo Werle*, Lowell Sandell, Simranpreet Kaur, Amit J. Jhala, John L. Lindquist; University of Nebraska-Lincoln, Lincoln, NE (115)

Giant ragweed is one of the most competitive weeds in corn and soybean production. In the western part of the Corn Belt, giant ragweed has been observed to emerge during early season in a short period of time. Glyphosate resistant giant ragweed populations have been confirmed in this region, making post-emergence management of this species even more difficult, especially in soybeans. Early spring tillage is being considered as an alternative tool for management of giant ragweed; however, soil disturbance could potentially stimulate more emergence. The objective of this study was to evaluate the influence of early season tillage on emergence pattern of a glyphosate resistant giant ragweed population from Nebraska. Field experiments were established in 2012 and 2013 at David City, NE, a site with confirmed glyphosate-resistant giant ragweed. Tillage treatments were conducted with a 50 cm wide rototiller operated at 15 cm depth, at four different times in the spring. The initial tillage treatment was on April 4 and April 18 for the 2012 and 2013 experimental years, respectively (onset of giant ragweed emergence in each year), and the subsequent three tillage times were conducted at 14 day intervals. A control treatment, where plots were not tilled, was also included in the study, for a total of five treatment levels. The experiment was arranged in a randomized complete block design. Plots were 1.5 by 4.6 m replicated four times. Emerged seedlings were counted and pulled on a weekly basis from three 0.3 by 0.3 m quadrats spaced 1.2 m apart in each plot starting early spring. A logistic function was fit to cumulative emergence regressed on day of year and the time to 50% emergence determined. The total number of emerged seedlings did not differ among treatments. However, total emergence was greater in 2012 (1535±147) than 2013 (543±147 seedlings $m^{-2}$ $year^{-1}$). The time to 50% emergence did not differ among treatments but differed between years (March 24±1 day and April 15±1 day in 2012 and 2013, respectively). Earlier emergence in 2012 and lower total emergence in 2013 can be explained by the extreme weather conditions observed in 2012 (above average temperatures during early season and drought conditions during summer and fall). According to our results, early season tillage did not stimulate giant ragweed emergence. Moreover, most of the seedlings emerged during early season in a short period of time, corroborating with emergence studies conducted in Iowa. Thus, tillage prior to crop planting but after most seedlings have emerged could be an alternative management option to control glyphosate-resistant giant ragweed populations in the western part of the United States' Corn Belt.

GIANT RAGWEED SEED PRODUCTION AND RETENTION IN SOYBEAN AND FIELD MARGINS. Jared J. Goplen*[1], Jeffrey L. Gunsolus[1], Craig Sheaffer[1], Roger Becker[1], Jeffrey Coulter[1], Fritz Breitenbach[2], Lisa M. Behnken[2], Gregg Johnson[3]; [1]University of Minnesota, Saint Paul, MN, [2]University of Minnesota, Rochester, MN, [3]University of Minnesota SROC, Waseca, MN (116)

In the Midwest, biotypes of giant ragweed (*Ambrosia trifida*) resistant to multiple herbicide sites of action have been identified. Weeds with multiple resistance reduces the efficacy of existing herbicides and developing herbicide-resistant crop technologies creating uncertainty in determining options for weed control, and decreasing profitability. With the increasing prevalence of herbicide-resistant giant ragweed, integrated methods of weed control are needed, including nonchemical technologies. Seed-destruction equipment that limits the amount of weed seed reentering the weed seed-bank can be an effective control strategy against herbicide-resistant weed species that retain their seed until crop harvest. Therefore, a better understanding of basic weed biology and ecology is necessary to determine applicability of seed destruction technologies. Seed rain of giant ragweed was monitored over two seasons to determine when giant ragweed naturally drops its seed. Seed collection traps were constructed to collect the seed of individual giant ragweed plants at weekly intervals in both soybean and in adjacent field margins. Seed collected was counted each week and categorized into hard (potentially viable) and soft (non-viable) seed based on a probe pressure test. In 2012, giant ragweed plants produced an average of 1796 ± 413 seeds per plant, with only 64% ± 4% of the seed being potentially viable. The giant ragweed began dropping seed the first week of September and continued through October. The seed tended to remain on the plant well into the fall, with 80% ± 4% of the potentially viable seed remaining on the plant at the end of October, which is after the typical harvest date for soybean. These results suggest that alternative weed management practices that capture or destroy giant ragweed seed at crop harvest have potential for being used in a giant ragweed management strategy, by limiting the replenishment of the seed-bank.

CONTROL OF GLYPHOSATE RESISTANT HORSEWEED WITH GLYPHOSATE DMA/2,4-D CHOLINE (ENLIST DUO) IN CORN. Laura R. Ford*[1], Darren Robinson[1], Allan McFadden[2], Nader Soltani[1], Robert Nurse[3], Peter H. Sikkema[1]; [1]University of Guelph-Ridgetown, Ridgetown, ON, [2]Dow AgroSciences Canada Inc, Guelph, ON, [3]Agriculture and Agri-Food Canada, Harrow, ON (117)

Glyphosate resistant horseweed (*Conyza Canadensis)* (GRH) was confirmed in Ontario from seed collections made in the fall of 2010. The repeated use of glyphosate on Roundup Ready (RR) crops has contributed to the selection of the resistant biotypes. An integrated approach that uses multiple modes of action is one component of an overall strategy to address glyphosate resistant weeds. Single versus sequential applications of glyphosate/2,4-D choline (Enlist Duo) and a two-pass weed control programs using preplant (PP) residual herbicides followed by post-emergence (POST) applied Enlist Duo have been evaluated. The single applications of Enlist Duo (1720 g ai ha$^{-1}$) provided 69-86% control of the GRH while the sequential applications increased control to 92-100%. Three applications of Enlist Duo did not provide an increase in control over two applications 8 weeks after the application (WAA). The PP residual herbicide that provided the most consistent control (95-99%) of GRH 8 WAA was s-metolachlor (1600 g ai ha-$^{1}$) + flumetsulam (50 g ai ha$^{-1}$) + clopyralid (135 g ai ha$^{-1}$). The PP residual herbicides followed by Enlist Duo (1720 g ai ha$^{-1}$) POST provided 97-100% control. Results from this research will help farmers implement the most efficacious herbicide program thereby maximizing GRH control, corn yield and net returns.

IMPACT OF HERBICIDES ON *CLAVIBACTER MICHIGANENSIS* SUBSP. *NEBRASKENSIS*, CAUSAL AGENT OF GOSS'S WILT OF CORN. Joseph Ikley*, Kiersten Wise, William G. Johnson; Purdue University, West Lafayette, IN (118)

Goss's bacterial wilt and leaf blight of corn is caused by the bacterium *Clavibacter michiganensis* subsp*. nebraskensis* (Cmn). This disease has recently become widespread throughout the Midwest and can cause up to a 44% yield loss in corn. Planting hybrids that have genetic resistance to the disease, along with tillage and rotating to a non-host crop are currently the recommended management options since there are no effective chemical management options. Some weed species have been documented to be a host of Cmn, therefore controlling weed hosts could reduce inoculum levels in a field. The objectives of this experiment were to apply single active ingredient herbicides to Cmn-infected weeds and corn and to (1) determine if virulent Cmn could be recovered from plants that did not survive treatment and (2) determine if disease severity in corn changed after herbicide application. In the greenhouse, three weed hosts and a susceptible corn variety were inoculated with a bacterial suspension containing 1 x $10^8$ colony-forming units (CFU) of Cmn per mL. One week after inoculation, visual symptoms were measured and recorded. Inoculated plants were arranged in a randomized complete block design with 5 replicates. Treatments consisted of seven herbicides and an untreated control. Two weeks after treatment, percent weed control and Cmn severity on corn were visually estimated. Leaf tissue from all plants were examined for bacterial streaming and plated onto Cmn-selective medium. Recovered bacteria were then used to inoculate a susceptible corn hybrid to test pathogenicity. Preliminary results indicate that the herbicides did not reduce the virulence of Cmn from treated weeds, regardless of control level. Corn treated with nicosulfuron had increased disease symptoms compared to other herbicide treatments and the untreated control. This study reinforces the importance of using preemergence weed control programs since weed debris may contain virulent Cmn and serve as a source of inoculum in corn. More research is needed to determine how herbicides alter Cmn severity in infected corn plants.

EFFECT OF HUMIDITY AND HUMECTANT ON GLUFOSINATE EFFICACY. Andrew R. Kniss[1], Carl W. Coburn*[1], Richard K. Zollinger[2]; [1]University of Wyoming, Laramie, WY, [2]North Dakota State University, Fargo, ND (119)

Previous research has demonstrated relative humidity (RH) after glufosinate application impacts efficacy. Growth chamber and field studies were conducted to determine whether a humectant could increase glufosinate efficacy in low RH environments. Common lambsquarters (*Chenopodium album*) was grown in growth chambers kept at 38% or 86% RH. Glufosinate was applied with ammonium sulfate alone or in combination with glycerol at 5% v/v. Immediately after spraying, plants were returned to either the same RH chamber or placed in the other chamber so that all combinations of RH environments before and after spraying were obtained. A three-parameter log-logistic model was used to quantify the response of common lambsquarters to glufosinate with and without glycerol for each RH environment. When humidity was high after glufosinate application, glycerol did not significantly affect the dose required to cause 90% injury (ED90) because efficacy was high regardless of glufosinate dose. Glycerol significantly decreased glufosinate ED90 when grown in low RH after treatment ($P>0.001$). Field studies conducted in Wyoming and North Dakota, however, did not support the findings from the growth chamber study. This discrepancy could possibly be explained by fluctuations in RH in the field compared to constant RH in growth chambers.

RESPONSE OF COMMON WATERHEMP TO WATERSTRESS. Debalin Sarangi*, John L. Lindquist, Suat Irmak, Amit J. Jhala; University of Nebraska-Lincoln, Lincoln, NE (120)

Common waterhemp (*Amaranthus rudis* Sauer) is one of the most problematic weeds in soybean and corn fields throughout the midwestern United States. Being a $C_4$ plant with rapid growth habit and prolific seed production ability, common waterhemp is one of the yield limiting factor. Climatic variability such as drought condition may affect common waterhemp growth and fecundity and the information is not available on response of common waterhemp to water stress condition. The objective of this study was to determine effect of degree and duration of water stress on common waterhemp growth, development, biomass, and fecundity. Plant height, number of leaves, and growth index was reduced with increasing level of water stress. Common waterhemp plants receiving water at 100% field capacity (FC) resulted in highest above ground biomass (81 g $plant^{-1}$) at harvest and highest total leaf area (5291 $m^2$ $plant^{-1}$) at peak growth stage. The most stressed plants (12.5 % of FC) did not produce any seed whereas, plants receiving water at 25% FC produced 1,566 seeds $plant^{-1}$. The results of another study to determine the effect of duration of water stress on common waterhemp suggested that plants receiving water at 10 d interval not only survived, but also resulted in about 50% of the above ground biomass, 40% of total leaf area and 7% of seed production compared to the plants receiving water at 2 d interval. The amount of water was more critical for growth and reproduction of common waterhemp compared to the water stress interval.

STATUS OF HERBICIDE RESISTANCE IN OHIO AMARANTHUS SPP. Samantha N. Konkle*, Mark M. Loux, Tony Dobbels; The Ohio State University, Columbus, OH (121)

Palmer amaranth (*Amaranthus palmeri*) is a weedy member of the *Amaranthus* family that has caused substantial problems in crop production in the southern United States due to the development of glyphosate-resistant populations. Soybean and cotton fields have suffered extreme or complete yield losses as a result of Palmer amaranth infestations. Palmer amaranth is a successful weed due to its rapid growth, prolific seed production, and its tolerance of postemergence herbicides. Until 2012, only one Ohio grower had experienced issues with Palmer amaranth, but Palmer amaranth was reported to be in a few more fields in 2013 following increased grower awareness about this weed. Proposed mechanisms of Palmer amaranth seed reaching Ohio include contaminated cottonseed products fed to livestock and contaminated seed used for CREP seedings. Ohio is, however, the home to other *Amaranthus* species including smooth pigweed (*Amaranthus hybridus*), redroot pigweed (*Amaranthus retroflexus*) and at much less frequency, waterhemp (*Amaranthus rudis*). Because Palmer amaranth is a threat to crop production, it is essential to stay ahead of any issues that may arise through close monitoring and screening. Our objectives were to: i) determine the frequency and distribution of *Amaranthus* populations in Ohio, and ii) determine the frequency of herbicide resistance in these populations. We conducted a survey of soybean fields just prior to harvest in 2012 and 2013 in 52 Ohio counties by driving transects of each county and assessing the level of infestation. Seed samples were collected from fields with infestations of *Amaranthus* spp. Growers were also asked, via newsletter articles, to send in seed samples from fields with an *Amaranthus* control problem. The survey covered 3994 and 3644 soybean fields in 2012 and 2013, respectively, and infestations of redroot pigweed occurred in only 12 and 34 fields. Infestations of waterhemp and Palmer amaranth were not observed. In contrast, we observed 88 and 540 infestations of giant ragweed and horseweed, respectively, in 2012 and 205 and 329 infestations in 2013. A greenhouse study was conducted with collected and submitted populations, to determine their response to glyphosate, and ALS- and PPO-inhibiting herbicides.

NITROUS OXIDE EMISSIONS AS INFLUENCED BY NITROGEN AND WEEDS BEFORE AND AFTER POSTEMERGENCE GLYPHOSATE APPLICATION. Rebecca R. Bailey*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (122)

Nitrous oxide ($N_2O$) emissions increase with increased soil nitrogen (N) and soil moisture. Weeds in a postemergence (POST) management system can potentially reduce $N_2O$ emissions by uptaking excess N and water while growing. However, after termination their residues can increase soil moisture and encourage N cycling, which could increase emissions. To investigate the effects of weeds and N on $N_2O$ emissions, a study was conducted in the greenhouse at the University of Wisconsin-Madison campus in spring 2013. The study was a completely randomized design with a 2x2 factorial arrangement of treatments including two weed densities (-W or +W) set as 0 or 100 plants $m^{-2}$, respectively, and two N rates (-N or +N) set as 0 or 200 kg N $ha^{-1}$, respectively. N was applied as ammonium nitrate when Powell amaranth (*Amaranthus powellii*), the weed used in the study, was seeded. Powell amaranth plants were sprayed with glyphosate at a rate of 0.87 kg ae $ha^{-1}$ plus ammonium sulfate at 2.9 kg $ha^{-1}$ when they were 10-15 cm tall. As the weeds perished, the residues were left on the soil surface. Gas samples (four $hour^{-1}$) were collected twice a week from the time of weed seeding until four weeks after glyphosate application from a static gas sampling chamber. The study was repeated in the field at the University of Wisconsin-Madison Arlington Agriculture Research Station during summer 2013. Modifications included using urea at 225 kg N $ha^{-1}$ for the +N treatments, seeding Powell amaranth to achieve a similar weed density as in the greenhouse, and allowing other naturally occurring weed populations to grow in the +W treatments. Additionally, acetochlor was soil surface applied at 2.63 kg ae $ha^{-1}$ and was also tank-mixed with POST applications of glyphosate at 1.57 kg ae $ha^{-1}$ to minimize weed emergence and the necessity for hand weeding in the weed-free treatments. In the greenhouse, the n*weed interaction was not significant p=0.133. However, the presence of weeds increased $N_2O$ emissions, where emissions for +W was 5.7 versus 2.6 mg $N_2O$-N $m^{-2}$ for -W (p=0.002). The addition of N also significantly increased emissions from 1.3 to 7.0 mg $N_2O$-N $m^{-2}$ for –N to +N, respectively (p=<0.0001). In the field, the n*weed interaction was not significant p=0.158. Similar to the greenhouse experiment, the +N treatments had significantly higher emissions (p=<0.0001), where emissions for the +N treatment was 234.5 versus 36.5 mg $N_2O$-N $m^{-2}$ for –N, but the presence of weeds did not influence emissions (p=0.155). These results agree with other studies that demonstrate higher N rates lead to increased $N_2O$ emissions. However, the impact of weeds on $N_2O$ emissions and the discrepancy between the greenhouse and the field need further evaluation and will be repeated.

## CONCOMITANT NUTRIENT RELEASE OF DECAYING WEED RESIDUES FOLLOWING POSTEMERGENT WEED CONTROL. Nick T. Harre*, Bryan G. Young, Jon E. Schoonover; Southern Illinois University, Carbondale, IL (123)

Substandard weed management practices are often a result of untimely herbicide applications to weeds that are beyond the critical duration of weed competition. Concurrent research has shown that increasing the duration of weed competition results in greater accumulation of nutrients by weeds, thereby impeding the process of soybean nutrient acquisition. Although herbicide applications made to large weeds is generally discouraged as a management practice, adequate control may still be achieved depending on the weed species present. However, a comprehensive explanation of the dynamics associated with the degradation of weed residues following postemergent control is lacking. Throughout the Midwest, two of the most prolific weed species existing in agronomic fields are waterhemp (*Amaranthus tuberculatus*) and giant foxtail (*Setaria faberi*). The vast prevalence of these species coupled with their affinity to competitively reduce soybean yields, suggests these are exemplary weed species to be used in the characterization of weed biomass degradation and to elucidate the ancillary effects of poor weed management due to delayed herbicide applications. *In situ* experiments were conducted in two soybean fields over a 16-week period in southern Illinois to quantify the rate of decomposition and nutrient release of waterhemp and giant foxtail desiccated by glyphosate at heights of 10, 20, 30, and 45 cm. Litterbag methodology was employed so that the mass and nutrient losses of weed residues could be measured over time. A geometric sampling schedule of 0, 2, 4, 7, 11 and 16 weeks was implemented in order to determine the extent of dry weight and nutrient loss, expressed using a decay constant (*k*), and regressed over time by the single exponential decay model. The initial concentration of cell wall components (cellulose, hemicellulose, and lignin) and the nutrients N and K were generally higher in giant foxtail whereas, C:N, P, Ca, Mg, and S were generally higher in waterhemp. Waterhemp decomposed 32% faster (*k*=0.128) than giant foxtail (*k*=0.097). Taller weeds contained greater concentrations of cell wall components, retained more mass (45 cm height; *k*=0.093), and liberated nutrients more slowly than smaller weeds (10 cm height; *k*=0.133). At the end of 16 weeks, 45-cm waterhemp had lost 81% of its original biomass compared to 91% by 10-cm waterhemp. Thus, the implementation of early-season weed management strategies can minimize the formation of recalcitrant plant substances thereby increasing the rate that nutrients are recycled and made bioavailable.

## THE APPLICABILITY OF TILMAN'S RESOURCE RATIO THEORY TO FOUR AMARANTHACEAE SPECIES. Lauren M. Schwartz*, Bryan G. Young, David J. Gibson; Southern Illinois University, Carbondale, IL (124)

The resource-ratio hypothesis of succession states that plant species are specialized on different proportions of limiting resources. Thus, if resource levels are sufficient, then the plant will have positive growth, and will draw down resource levels leading to a reduction in population growth rate. Since different plant species use the same major resources, then the resource-ratio hypothesis predicts that the species that can maintain a positive growth rate at the lowest resource level will be the best competitor for that resource. Four species within the Amaranthaceae family were studied in southern Illinois to test the applicability of the resource ratio theory. *Amaranthus palmeri* and *A. rudis* are summer annuals typically found as problematic agricultural weeds. *Achyranthes japonica* and *Iresine rhizomatosa* are two perennial species that occur in similar habitats but differ in invasiveness. *Achryanthes japonica* is a non-native, invasive species that is becoming a threat to natural forested areas and has also been observed on agricultural field margins. *Iresine rhizomatosa* also occurs in forest habitats but is an endangered species in Illinois. The objective of this experiment was to determine the relative competitive effect and response of the four closely related species in comparison to *Glycine max*. A greenhouse experiment was conducted, in which each of the four Amaranthaceae species were grown with soybean (*G. max*), were evaluated in a closed system to assess resource drawdown by each species of an aboveground (light) and belowground (nitrogen) resource. A resource manipulation treatment was implemented by adding nitrogen in the form of ammonium nitrate and by shading using a 60% shade cloth. Total nitrogen drawdown was significantly higher in the shaded treatments when ammonium nitrate was added, but there was not a species interaction (P=0.0003). In both trials, there was a highly significant three-way interaction between species, shading treatment, and day (P=0.0002). Aboveground biomass both had a significant interaction between species and both treatments (nitrogen: P=0.08; shading: 0.006), individually. Belowground biomass, however, had a significant three-way interaction between species and both treatments (P=0.009). The shading treatment reduced the overall size of the *Amaranthus* species, whereas the perennials grew better, in comparison to the non-shaded treatment. *Achyranthes japonica* produced the most belowground biomass out of the four Amaranthaceae species in all treatment groups. *Amaranthus palmeri* and *A. japonica* had an increased amount of aboveground biomass when nitrogen was added. In the shading treatment, however, all species had a decreased amount of aboveground biomass in comparison to the controls. *Glycine max* had the greatest abundance of biomass regardless of treatment. Therefore, *A. japonica* could be a competitor to the *Amaranthus* species based on biomass, nitrogen drawdown, and shade tolerance. Applicability of the resource ratio theory could lead to more effective weed management tactics by allowing prediction of susceptible areas of infestation or competitive outcomes based on resource levels.

## THE EFFECT OF MOB GRAZING ON CANADA THISTLE CONTROL, PASTURE PRODUCTIVITY AND UTILIZATION, AND FORAGE QUALITY.

Anders M. Gurda*[1], Mark J. Renz[1], Geoffrey E. Brink[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]USDA-ARS Dairy Forage Research Center, Madison, WI (125)

Canada thistle (*Cirsium Arvense*) has been identified as a problem weed in Wisconsin pastures. It can reduce forage yield and utilization, negatively impacting animal performance. While abatement typically involves the use of herbicides, few studies have accounted for the negative impacts on desirable legume forages or compared results to methods that utilize increased stocking densities to facilitate weed control by grazing. Our research compared the efficacy of a fall herbicide application, two mob grazing treatments (one and two consecutive years), and a rotationally grazed control on Canada thistle populations and the resulting forage production and utilization. Research was conducted at three sites in southern Wisconsin representing a diversity of pasture productivity and composition. At each site, paddocks were arranged in a randomized complete block design consisting of four replications. Aminopyralid + 2,4-D (120+970 g ae $ha^{-1}$) was applied the fall of 2011 as the herbicide treatment. Rotationally grazed treatments were grazed 3-4 times in 2012 and 2013 when forage was greater than 20 cm and grasses were not flowering. Mob grazed plots were grazed twice when the sward was >36 cm, grasses were flowering, and Canada thistle was in the flower bud to flowering stage. All treatments were grazed to a 10 cm residual and allowed to recover until the specified height was reached. Stocking densities were 70 and 450 Mg $kg^{-1}$ for the rotationally grazed and Mob treatments, respectively. Productivity, utilization and effects on Canada thistle in 2013, two years after establishment, are presented. Forage available was 24-75% more in the treatments Mob grazed for two years compared to other treatments at two of the three sites in 2013. Forage utilization also increased when Mob grazed for two consecutive years, with two to three fold higher utilization in 2013 at two of three sites. Mob grazing increased Canada thistle utilization at one of three sites. Although Mob grazing has not provided improved suppression after two years, the increased forage available and utilized suggests that mob grazing may result in improved animal performance if forage quality can be maintained.

## EFFECT OF IMAZETHAPYR, MESOTRIONE AND SAFLUFENACIL RESIDUES ON FOUR SPRING-SEEDED COVER CROPS.

Li Yu*, Darren Robinson, Peter H. Sikkema; University of Guelph-Ridgetown, Ridgetown, ON (126)

*NO ABSTRACT SUBMITTED*

## A MULTI-STATE STUDY OF THE ASSOCIATION BETWEEN GLYPHOSATE RESISTANCE AND EPSPS GENE AMPLIFICATION IN WATERHEMP.

Laura A. Chatham*[1], Chance W. Riggins[1], James R. Martin[2], Greg R. Kruger[3], Kevin W. Bradley[4], Dallas E. Peterson[5], Mithila Jugulam[5], Patrick Tranel[1]; [1]University of Illinois, Urbana-Champaign, IL, [2]University of Kentucky, Princeton, KY, [3]University of Nebraska-Lincoln, North Platte, NE, [4]University of Missouri, Columbia, MO, [5]Kansas State University, Manhattan, KS (127)

Since the commercialization of glyphosate-resistant crops and the discovery of the first glyphosate-resistant weed in 1996, weed resistance to glyphosate has become increasingly problematic. Glyphosate resistance has now been found in 24 different weed species across 21 countries. The mechanism of glyphosate resistance in Palmer amaranth (*Amaranthus palmeri*) was found to be gene amplification of the target-site gene 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS). The purpose of this research was to determine whether EPSPS gene amplification is associated with glyphosate

resistance in waterhemp (*Amaranthus tuberculatus*) by examining the relationship between application rate and EPSPS copy number of survivors. Research sites with glyphosate-resistant waterhemp were selected from Illinois, Missouri, Kansas, Nebraska and Kentucky. Plots were sprayed with 0x, 0.5x, 1x, 2x, and 4x rates of glyphosate (1x = 840 g ae/ha), and survivors were selected for relative copy number analysis via qPCR. Waterhemp control increased with increasing glyphosate rate at all locations. Elevated EPSPS copy number was present in four out of the five locations tested. In general, the proportion of plants with elevated copy number was higher in glyphosate-treated plots compared to untreated control plots. How well the data fit this trend depended on a variety of factors, including: inherent frequency of elevated copy number and the magnitude of copy number increase in the population (both of which varied by location), herbicide rate, and the threshold value used to define elevated copy number. Samples from the Kentucky population, which did not have elevated copy number, were subjected to a dCAPS assay designed to detect the EPSPS Pro106Ser mutation in waterhemp. Results indicated that the mutation was present in this population, and this result was confirmed by DNA sequencing of several samples. The proportion of survivors carrying the mutation increased with increasing rate, suggesting the Pro106Ser target-site mutation is responsible for resistance in the Kentucky population. We conclude that EPSPS gene amplification is associated with resistance in some glyphosate-resistant waterhemp populations, but other resistance mechanisms are also present.

## NON-TARGET-SITE RESISTANCE TO ALS INHIBITORS IN WATERHEMP.

Jiaqi Guo*, Chance W. Riggins, Nicholas Hausman, Aaron G. Hager, Dean E. Riechers, Patrick Tranel; University of Illinois, Urbana-Champaign, IL (128)

Waterhemp (*Amaranthus tuberculatus*) is considered one of the most problematic weeds in the Midwest cropping region. The evolution of herbicide resistance and multiple resistance mechanisms within the species is one of the major properties making it difficult to control. A waterhemp population (designated MCR) from Illinois with resistance to HPPD and PSII inhibitors was found to segregate for both high and moderate levels of resistance to ALS inhibitors. Plants in this population with high-level resistance had the Trp574Leu ALS mutation, which has been shown previously to be present in other waterhemp population resistant to ALS inhibitors. Plants from the MCR population that showed only moderate levels of resistance to ALS inhibitors did not have this mutation. Thus, research was conducted to investigate the resistance mechanism in the waterhemp plants with moderate resistance to ALS-inhibitors. Plants with moderate resistance were crossed and the resulting progeny where characterized. Firstly the ALS gene of the progeny was sequenced and *in vitro* ALS enzyme assays were conducted, and results indicated that the plants lacked a target-site mutation. Secondly, a series of greenhouse dose-response experiments were conducted to evaluate the resistance level across different chemical families of ALS-inhibitors. Thirdly, malathion, a P450s-inhibiting pesticide, was incorporated with ALS-inhibitor application to unveil the possible mechanism of resistance. Based on the results obtain, it was concluded that both target-site-mutation-based and metabolism-based ALS resistance mediated by cytochrome P450s is proposed to exist in the original MCR population.

## ABSORPTION AND TRANSLOCATION OF 2,4-D IN RESISTANT AND SUSCEPTIBLE *AMARANTHUS TUBERCULATUS*.

Lacy J. Valentine*[1], J. Mithila[2], Amar S. Godar[2], Zac Reicher[1], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Kansas State University, Manhattan, KS, [3]University of Nebraska-Lincoln, North Platte, NE (129)

A 2,4-D resistant common waterhemp population was investigated for reduced absorption and translocation as a possible mechanism for resistance. Carbon-14[$^{14}$C] 2,4-D was applied to one leaf per plant of a known 2,4-D-susceptible common waterhemp population and the confirmed 2,4-D-resistant common waterhemp population when plants reached 8-10 cm in height. Treated leaves were rinsed and rinsate collected 6, 24, 48, 72, 96 hours after treatment (HAT) to determine amount of [$^{14}$C] 2,4-D absorbed. Plants from resistant and susceptible populations absorbed 49.0% and 51.0% [$^{14}$C] 2,4-D, respectively. The treated leaf (TL), aboveground plant tissue below the treated leaf (BTL), plant tissue above the treated leaf (ATL), and below ground plant tissue (BG) were harvested 6, 24, 48, 72, 96 HAT to determine the translocation of absorbed [$^{14}$C] 2,4-D. There was no difference in the translocation of [$^{14}$C] 2,4-D between the resistant and the susceptible population with exception of what was translocated to below the treated leaf tissues. Plants from susceptible population translocated 1% more [$^{14}$C] 2,4-D to BTL than resistant population. The results from these experiments provide evidence that 2,4-D resistant common waterhemp plants absorb and translocate the same amount of applied 2,4-D as susceptible plants. Furthermore, although resistant and susceptible plants translocate the same amount of 2,4-D after absorption, susceptible plants translocate more 2,4-D to below the treated leaf tissue. Further experimentation is needed to assess the mechanism of 2,4-D resistance in common waterhemp.

## MESOTRIONE RESISTANCE IS INCREASED UNDER ELEVATED GROWTH TEMPERATURES IN PALMER AMARANTH.

Amar S. Godar, Mithila Jugulam*, P. V. Vara Prasad; Kansas State University, Manhattan, KS (130)

Herbicide efficacy is known to be influenced by environmental conditions, including temperatures under which weeds are grown. Hydroxyphenylpyruvate dioxygenase (HPPD)-inhibitors are widely used in sorghum and corn to control a number of weeds including Palmer amaranth (*Amaranthus palmeri*). Recently, Palmer amaranth populations from Kansas were reported to have evolved resistance to several HPPD-inhibitors, including mesotrione. Short episodes of high temperature during the summer months are common in the central Great Plains. The objective of this study was to evaluate the response of Palmer amaranth HPPD-inhibitor-susceptible (KS-MS) and -resistant (KS-MR) populations to mesotrione under low (20/10 C d/n), optimum (30/20 C d/n), and elevated (40/30 C d/n) temperature conditions. Individual plants were grown under above temperatures in growth chambers. When plants were 8-12 cm tall, they were treated with 105 g ai/ha (field use rate) of mesotrione. Subsequently, 1, 2 and 4 weeks after treatment (WAT), visual injury, plant height and chlorophyll content were measured. Additionally, mortality counts and aboveground dry biomass were determined 4 WAT. Results from these experiments suggest that, in response to mesotrione application, both KS-MS and KS-MR populations produced less biomass (expressed as percent of untreated) when grown under low compared to optimum or elevated growth temperature conditions. Visual injury and plant height correlated with biomass results. Furthermore, 2 to 4 WAT, Palmer amaranth plants grown under low temperatures were severely injured and did not show any recovery; whereas, plants grown under optimal or elevated temperatures recovered from mesotrione injury. These results suggest that mesotrione efficacy can be improved if applied during cooler temperature conditions; however, further research is needed to ensure crop safety, especially in sorghum.

## *AMARANTHUS* SPECIES: POLLEN EXPRESSION OF EPSP SYNTHASE AND *IN VITRO* POLLEN GERMINATION.

Tye C. Shauck*, Reid J. Smeda; University of Missouri, Columbia, MO (131)

Pollen transfer between *Amaranthus* species is a method by which herbicide resistance can spread quickly across crop landscapes. Quick methods for confirming glyphosate-resistance (GR) will facilitate management techniques when resistance is suspected. *In vitro* pollen tube germination assays have been used previously to identify ALS and ACCase target-site resistance. However, it is unclear whether GR is expressed in the pollen of significant weed species. The objectives of this study were to determine: a) expression of 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) in common waterhemp (*Amaranthus rudis*), Palmer amaranth (*Amaranthus palmeri*), common ragweed (*Ambrosia artemisiifolia*), and giant ragweed (*Ambrosia trifida*) pollen; b) presence of target-site resistance mechanisms; and c) growth of pollen tubes of glyphosate-susceptible (GS) and GR common waterhemp and Palmer amaranth in the presence of glyphosate. Western blots were used to identify expression of EPSPS in pollen. Reverse transcription polymerase chain reaction (rtPCR) was used to sequence EPSPS to determine the presence of target site mutations. Additionally, quantitative PCR (qPCR) was utilized to determine overexpression of EPSPS. Western blots and rtPCR confirmed the expression of EPSPS in pollen from all species. No target-site mutations were identified in GR common waterhemp or Palmer amaranth. GR common waterhemp did not overexpress EPSPS. However, GR Palmer amaranth leaf tissue and pollen contained 110- and 92-fold more copies of EPSPS than the GS biotype, respectively. An *in vitro* assay using agarose was developed to determine pollen tube growth in the presence of glyphosate. Glyphosate was incorporated into the germination media at concentrations of 0, 0.0005, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 20, and 30 mM. Pollen was collected from cloned waterhemp and Palmer amaranth plants every other day by vacuum filtration and stored at -80 C. Pollen was incubated on germination media at 33 C for 3 hours to allow pollen germination and pollen tube growth. Following incubation, pollen was stained with toluidine blue and stored at 5 C to terminate growth. GS and GR common waterhemp and Palmer amaranth pollen tube growth was sensitive to increasing glyphosate concentrations. However, there were no differences in pollen tube growth between GS and GR plants. Pollen tube length was reduced by 50 and 80% at 0.01 and 1 mM glyphosate for GS and GR common waterhemp compared to the untreated, respectively. Palmer amaranth pollen tube growth was more variable and overall less sensitive to glyphosate. Pollen tube length was not reduced more than 55% at glyphosate concentrations up to 30 mM for GS and GR Palmer amaranth compared to the untreated. Overall, GR was not expressed in pollen using a pollen tube growth assay in the presence of glyphosate. Pollen tube growth assays do not appear to be a method to discriminate between GS and GR weed species, despite the presence of EPSPS in pollen.

NEW EVIDENCE FOR MULTIPLE GLYPHOSATE-RESISTANCE MECHANISMS WITHIN A POPULATION OF COMMON RAGWEED. Jason T. Parrish*[1], Mark M. Loux[1], David M. Mackey[1], Leah K. McHale[1], Doug Sammons[2], Dafu Wang[2], Elizabeth L. Ostrander[3], Dana A. d'Avignon[3], Xia Ge[3], Philip Westra[4], Christopher R. Van Horn[4], Andrew T. Wiersma[5]; [1]The Ohio State University, Columbus, OH, [2]Monsanto Company, St. Louis, MO, [3]Washington University, St. Louis, MO, [4]Colorado State University, Fort Collins, CO, [5]Michigan State University, East Lansing, MI (132)

Common ragweed (*Ambrosia artemisiifolia*) is a weed problem in many places throughout the world. Though it seldom dominates the landscape, common ragweed seems to be able to exploit diverse habitats. The genetic diversity may also play a role in the development of herbicide-resistant biotypes. Studies were conducted to determine the mechanisms of resistance to glyphosate in an Ohio ragweed population, including 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) gene sequencing, EPSPS enzyme immunoblot and activity/inhibition assays, $^{31}$P-nuclear magnetic resonance (NMR) studies of glyphosate-treated tissues, and whole-plant absorption and translocation studies using $^{14}$C-labeled glyphosate. The molecular basis for resistance is still unclear. The gene coding for EPSPS has a high mutation rate in common ragweed, but typically does not code for an altered amino acid sequence in the glyphosate binding area. Recent experiments have located alleles of EPSPS coding for proline to serine and proline to threonine substitutions at amino acid #106. This locus was not detected in previous experiments, and it is not known whether these alleles are translated into a functional EPSPS protein. These data also suggest that there are 6 or more partial- or full-length copies (3 or more loci) of the EPSPS gene in a typical diploid common ragweed plant. An immunoblot assay with common ragweed total soluble protein, as well as Palmer amaranth (*Amaranthus palmeri*) controls, showed a single plant from this same glyphosate-resistant population with increased EPSPS expression. $^{31}$P-NMR data shows efficient uptake of glyphosate into the cell and no vacuolar sequestration in this glyphosate-resistant population, with lower sugar-phosphate accumulation relative to glyphosate-susceptible common ragweed plants. Similarly, no reduced absorption or translocation of $^{14}$C-labeled-glyphosate was ascertained over 48 hours, though subjective evidence from other experiments indicates some sort of non-target-based mechanism could contribute to glyphosate resistance in a large or minor way.

UPTAKE, TRANSLOCATION, AND METABOLISM OF 2,4-D IN ENLIST SOYBEANS. Joshua J. Skelton*[1], David M. Simpson[2], Dean E. Riechers[1]; [1]University of Illinois, Urbana-Champaign, IL, [2]Dow AgroSciences, Indianapolis, IN (133)

The Enlist™ Weed Control System provides a new, novel means of conferring 2,4-D tolerance in several crops including soybeans. Enlist Duo is a premix of 2,4-D choline + glyphosate being developed for use in Enlist™ crops. Insertion of the *aad-12* gene, which encodes the bacterial aryloxyalkanoate dioxygenase enzyme, confers plants with the ability to rapidly metabolize 2,4-D to dichlorophenol. Much is known about the AAD-12 enzyme and catalyzed reaction, but less has been reported on 2,4-D choline uptake, translocation and metabolism in Enlist™ soybeans. To gain insight into uptake, translocation, and metabolism of 2,4-D choline in Enlist™ soybeans, two different growth chamber studies using whole plants were conducted in 2013. Experiments utilizing [URL-$^{14}$C]-2,4-D were conducted to determine how 2,4-D uptake, translocation, and metabolism were influenced by herbicide formulation in Enlist™ soybeans during a time course study. Herbicide uptake was affected by the herbicide treatments. In the first experiment, treatments containing Enlist™ Duo or 2,4-D choline plus an adjuvant blank (from the Enlist™ Duo herbicide formulation, a premix of 2,4-D choline + glyphosate) displayed greater and more rapid herbicide uptake compared to 2,4-D choline treatment without the adjuvant. In the second experiment, even though all treatments had the same adjuvant, the Enlist™ Duo formulation uptake was significantly greater than the other treatments. Translocation of 2,4-D out of treated leaf was minimal with 98% remaining in the treated leaf at 24 hours. Significant differences were not detected in acropetal or basipetal translocation patterns of $^{14}$C material. The Enlist™ soybeans had more 2,4-D acid present in the treated leaf at 1, 3, 6 and 24 hours when treated with Enlist™ Duo compared to 2,4-D choline with or without adjuvant treatment. These studies provide a better understanding of the influence of Enlist™ Duo herbicide on 2,4-D metabolism, translocation and uptake in Enlist soybean. Further research into the initial herbicidal activity of 2,4-D that may occur when increased uptake results in a transient elevation in 2,4-D concentrations in Enlist™ crops will clarify why necrosis in treated leaves may occur.

™Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow. Regulatory approvals are pending for the Enlist herbicide solution and crops containing Enlist herbicide tolerance traits. The information presented here is not an offer for sale. Always read and follow label directions. ©2013 Dow AgroSciences LLC

KOCHIA POPULATIONS RESPONSE TO GLYPHOSATE AND EPSPS GENE COPY NUMBER. Amar S. Godar*[1], Phillip W. Stahlman[2], Mithila Jugulam[1], Anita Dille[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS (134)

Elevated tolerance to glyphosate in kochia [*Kochia scoparia* (L.) Schard] populations was reported in western Kansas during the mid-2000's. Kochia populations in the region were confirmed resistant to glyphosate in 2007. In this study, 40 kochia populations collected in 2012, mostly from western Kansas, were evaluated for resistance to glyphosate and EPSPS gene copy number. All populations were initially evaluated by treating 10-12 cm tall plants (n=72, per population) with 0.84 kg ae $ha^{-1}$ glyphosate and 2% AMS (w/v). Resistance level of individual plants (n=32, per population) from six selected populations were further evaluated with a series of glyphosate doses (0.21 to 5.04 kg ae $ha^{-1}$) and 3 to 9 plants per population were selected for EPSPS gene copy number determination. EPSPS gene copy number (relative to the number in susceptible population) was determined using fluorescence-based (SYBR Green) quantitative PCR method. Kochia populations showed varied response to 0.84 kg ae $ha^{-1}$ glyphosate 18 d after treatment, ranging from 0 to 100% mortality. Many Kansas populations and two of three populations from Oklahoma exhibited definitive levels of glyphosate resistance (survived 0.84 kg ae $ha^{-1}$ glyphosate with <30% injury). Nearly one-half of the populations from Kansas and those from Idaho and South Dakota showed elevated tolerance to glyphosate (survived 0.84 kg ae $ha^{-1}$ glyphosate but with >60% injury). EPSPS gene copy number in resistant populations correlated with glyphosate resistance level and the number ranged from 5 to 7 and 9 to 13 in plants that survived 1.26 kg ae $ha^{-1}$ glyphosate with 60 to 80% and 25 to 35% injury, respectively. The copy number ranged from 12 to 16 in those plants that survived 5.04 kg ae $ha^{-1}$ glyphosate with 80 to 95% injury. No clear evidence of increased EPSPS gene copy number was observed in plants from populations that showed elevated tolerance up to five-fold compared to the most sensitive population; however, methods that can precisely detect small fold change in copy number such as probe-based (TaqMan) qPCR or digital PCR method is suggested for more confirmative result. Increased EPSPS gene copies in glyphosate-resistant kochia populations has been documented previously; however, mechanism of elevated tolerance remains unknown

EVOLUTION AND STATUS OF GLYPHOSATE RESISTANT KOCHIA IN AMERICAN GREAT PLAINS. Philip Westra*[1], Andrew T. Wiersma[2]; [1]Colorado State University, Fort Collins, CO, [2]Michigan State University, East Lansing, MI (135)

Kochia populations that survive labeled rates of glyphosate have been documented in TX, OK, KS, CO, NE, SD, ND, MT, Alberta, and Saskatchewan. These populations are frequently identified as "green streaks or trails" of surviving plants in fallow or crop fields where all other kochia plants are well controlled. Greenhouse dose response studies frequently show that such populations are still segregating for the level of glyphosate resistance, but some will survive up to 6 kg/ha of glyphosate in greenhouse studies. Resistance due to differential glyphosate uptake and translocation has largely been eliminated as the mechanism of resistance. Molecular and genomic research, however, has shown that all glyphosate resistant kochia plants evaluated to date do exhibit EPSPS gene amplification, similar to what was documented in Palmer amaranth, although the gene copy number is much lower than was observed in Palmer amaranth. Transcriptome sequence of kochia RNA demonstrated that of the key enzymes involved in the corismate pathway, only EPSPS is significantly up regulated in glyphosate resistant kochia plants. The tumbleweed biology of kochia presents a unique and powerful method for the rapid spread of the glyphosate resistant trait across the landscape. A coordinated regional effort to conduct kochia research over the next several years is emerging from the collaborative research being conducted at the field, lab, and molecular level with kochia.

### THE INFLUENCE OF CARRIER VOLUME AND SPRAY NOZZLE TYPE ON HERBICIDE COVERAGE AT LATE POST APPLICATION TO 31-CM TALL SOYBEAN. Travis Legleiter*, William G. Johnson; Purdue University, West Lafayette, IN (136)

Concerns of herbicide drift with the approaching release of dicamba and 2,4-D resistant soybean have resulted in the recommended use of venturi air induction nozzles that produce larger, less drift-able droplets. Trials were conducted in 2012 and 2013 in West Lafayette, Indiana to determine the influence of spray nozzle type and spray volume on herbicide coverage of weeds at three heights in 31 cm tall soybean. A factorial trial design was used with nozzle type and spray volume as factors. Spray nozzle types evaluated were TeeJet brand extended range (XR), air induction extended range (AIXR), Turbo Tee (TT), and Turbo Tee Induction (TTI) at spray volumes of 96 and 144 L/Ha. Water sensitive cards placed in the soybean canopy at 3 heights above the ground: 10, 20, and 30 cm to evaluate spray coverage. Coverage of herbicide on cards, regardless of spray tip and spray volume, was 13% less in 2013 than 2012 due to differences in soybean canopy development. Coverage was reduced significantly on cards lower in the soybean canopy than cards at the top of the canopy. Coverage was positively correlated with spray volume at all card heights for all spray tips in both years. Coverage at the lowest height, where target weeds are likely to be found at late post applications, was not reduced by TTI and AIXR nozzles producing very coarse to ultra course tips when applied at 96 L/Ha. A nozzle and spray volume combination that consistently produced the best or worst coverage was not observed. Results of these trials show that applications with the nozzles producing larger, less drift-able droplets do not necessarily reduce spray coverage of small target weeds at late post applications timings and that a multitude of factors beyond nozzle type and spray volume influence coverage.

### INTERACTION OF CARRIER WATER PH AND HARDNESS ON THE EFFICACY OF MON 76757 AND 2,4-D CHOLINE. Pratap Devkota*, William G. Johnson; Purdue University, West Lafayette, IN (137)

Herbicide carrier water contains various levels of hardness and pH depending upon the underground source. Hard water cations and water pH can interact with the herbicide and influence weed control. Field studies were conducted to evaluate the effect of carrier water pH and hardness on efficacy of MON 76757 (a formulated premix of glyphosate + dicamba) and 2,4-D choline. Treatments consisted of carrier water pH at 4, 6.5, and 9; and water hardness at 0 (DI water), 400, and 800 ppm $CaCO_3$ equivalent. MON 76757 was applied at 2.32 L/ha (glyphosate at 1.11 kg ae/ha plus dicamba at 0.55 kg ae/ha) and 2,4-D choline was applied at 1.12 kg ae/ha (2.46 L/ha) at 10 and 7 inches tall common ragweed and horseweed, respectively. Weed density (plants/$m^2$ before spraying and after the final rating), % weed control, and oven dried shoot biomass (above ground shoot harvested per $m^2$) was recorded. There were no interactions between carrier water pH and hardness on MON 76757 and 2,4-D choline efficacy. Carrier water pH did not have significant effect on MON 76757 and 2,4-D choline. However, the water hardness had a significant effect on MON 76757 and 2,4-D choline. At 4 wk after application, MON 76757 provided lower control of common ragweed and horseweed with hard water compared to the control with DI water. Similarly, 2,4-D choline provided lower control of common ragweed and horseweed than in DI water. The end-of-season weed count and dried shoot biomass did not differ for MON 76757 and 2,4-D choline applied with varying level of water hardness. In conclusion, carrier water hardness is critical for MON 76757 and 2,4-D choline application.

### INCREASING ACTIVITY OF GROWTH REGULATOR HERBICIDES WITH WATER CONDITIONERS. Donald Penner*, Jan Michael; Michigan State University, East Lansing, MI (138)

Water conditioners have been shown to increase the herbicidal activity of glyphosate and glufosinate in hard water. The growth regulators, 2,4-D and dicamba, are also weak acids and potentially their activity could be increased with the use of water conditioners. The objective of this study was to determine the efficacy of several water conditioners in enhancing the herbicidal activity of two formulations of 2,4-D and dicamba in greenhouse studies. The control of velvetleaf and common lambsquarters was evaluated 7, 10, 14 and 21 days after herbicide application. Weed control was greater with all the water conditioners tested. The magnitude of activity enhancement was similar to that obtained with the addition of the same water conditioners to glyphosate.

GLYPHOSATE, FLUAZIFOP, LACTOFEN, AND DICAMBA EFFICACY AND DROPLET SIZE AS INFLUENCED BY ADJUVANTS. Cody F. Creech*[1], William E. Bagley[2], Lowell Sandell[3], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Wilbur-Ellis, San Antonio, TX, [3]University of Nebraska-Lincoln, Lincoln, NE (139)

The potential activity of postemergence herbicides often is limited by the inability of the herbicide to adequately cover or penetrate the leaf surface. Furthermore, information on herbicide labels are generally limited in describing the use of adjuvants to optimize herbicide performance. This field study evaluated the impact of different types of adjuvants on herbicide efficacy and droplet spectra. Replicated studies were located in Minden, York, Pierce, and Waterloo, NE. The treatments consisted of four herbicides applied at half the labeled rate, a non-surfactant loaded glyphosate (0.79 kg ae/ha), fluazifop (0.07 kg ai/ha), lactofen (0.11 kg ai/ha) and dicamba (0.14 kg ae/ha). These four herbicides represented an EPSP synthase inhibitor, ACCase inhibitor, PPO inhibitor, and a synthetic auxin, respectively. Each herbicide was applied alone and in combination with a non-ionic surfactant (NIS), crop oil concentrate (COC), methylated seed oil (MSO), high surfactant oil concentrate (HSOC), ammonium sulfate (AMS), and a drift reduction technology adjuvant (DRT). The adjuvants were applied at the full rates commonly recommended on labels as follows: NIS (0.25% v/v), COC (1% v/v), MSO (1% v/v), HSOC (1% v/v), AMS (17 lb ai/100 gal), and DRT (4 fl oz/a). Plots were 3 meters wide and 8 meters long and had a naturally occurring weed population that had also been supplemented by broadcasting velvetleaf (*Abutilon theophrasti*), grain amaranth (*Amaranthus hypochondriacus*), Palmer amaranth (*Amaranthus palmeri*), flax (*Linum usitatissimum*), and barnyard grass (*Echinochloa crus-galli*). The glyphosate, fluazifop, and dicamba were applied at 38 L/ha using an AIXR110015 nozzle and the lactofen was applied at 76 L/ha using an AIXR11003 nozzle. Treatments were applied using a $CO_2$ pressurized backpack sprayer. Visual estimations of injury were collected at 7, 14, and 28 days after treatment (DAT) using a scale of 0 – 100 where 0 = no injury and 100 = plant death. Generally, the addition of adjuvants increased the efficacy of the four herbicides tested. The adjuvants performed differently with each herbicide and were often species specific. The addition of adjuvants is imperative to get the most out of every herbicide application, but further testing is needed to understand which situations are best suited for different application conditions and intended targets.

TOMATO INJURY AND DOWNWIND DEPOSITION FROM AERIAL APPLICATIONS OF GLYPHOSATE. Ryan S. Henry*[1], Brad Fritz[2], Clint Hoffmann[2], William E. Bagley[3], Andrew Hewitt[1], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]USDA-ARS, College Station, TX, [3]Wilbur-Ellis, San Antonio, TX (140)

Studies examining the drift potential of a pesticide application have historically measured only the amount of pesticide downwind of the application site. This is commonly done using a fluorescent dye as a proxy for the active ingredient and capturing the dye using sample media such as mylar plates, petri dishes, or strings. The present study combines this technique with a sensitive plant to serve as bio-indicators of pesticide drift. Two pesticide solutions were applied using an Air Tractor 402B aircraft at 135 mph into a wheat stubble field. Downwind sampling of pesticide drift was made using mylar plates, tomato (*Solanum lycopersicum*), and monofilament strings up to 210 feet away from the application site. Visual damage was observed on the tomato plants at virtually all sampling locations, although deposition data from the mylar plates was less than one percent of the applied rate at far downwind sampling locations. This experiment highlights the importance of using bio-indicators in future drift studies and will aid in improving application technologies and regulations.

GLYPHOSATE DRIFT DEPOSITION AND TOMATO INJURY FROM GROUND APPLICATIONS. Greg R. Kruger*[1], Ryan S. Henry[1], Cody F. Creech[1], Brad Fritz[2], Clint Hoffmann[2], William E. Bagley[3], Andrew Hewitt[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]USDA-ARS, College Station, TX, [3]Wilbur-Ellis, San Antonio, TX (141)

*NO ABSTRACT SUBMITTED*

DOSE RESPONSES OF SILVERY-THREAD MOSS TO APPLICATIONS OF CARFENTRAZONE-ETHYL. Zane M. Raudenbush*, Steven J. Keeley, Mithila Jugulam; Kansas State University, Manhattan, KS (142)

Silvery-thread moss (*Bryum argenteum* Hedw.) is a problematic weed in creeping bentgrass putting greens. In the United States, Quicksilver™ (a.i. carfentrazone-ethyl) is labeled for selective control of silvery-thread moss; however, researchers have reported a wide range of efficacy. Therefore, the objective of our research was to determine silvery-thread moss injury from selected doses of carfentrazone-ethyl under greenhouse conditions. Silvery-thread moss was collected from a putting green in Kansas and propagated in a greenhouse at Kansas State University. Three months prior to treatment initiation, moss was established in 2.5 cm dia. x 13 cm deep cone-tainers filled with sand meeting specifications for USGA putting greens. In experiment 1, carfentrazone ethyl was applied at 0.027, 0.055, 0.111, 0.223, 0.446, and 0.893 kg ai ha$^{-1}$; and in experiment 2, rates were 0.014, 0.027, 0.055, 0.111, 0.223, and 0.446 kg ai ha$^{-1}$. All treatments included a nonionic surfactant applied at 0.25% v/v, and an untreated water-control was included for comparison. Cone-tainers were watered daily throughout the experiments to prevent drought stress. Applications were made using a spray chamber operating at 124 kPa with a spray volume of 186 L ha$^{-1}$. A completely randomized design with five replications was used to visually estimate moss injury (1= no injury, green; 9= complete tissue burn, black) weekly until 8 WAT. At week 8, moss was harvested, dried at 80°C for 3 d, and dry weight was recorded. Amplex® red hydrogen peroxide assay kits were used to determine $H_2O_2$ production for carfentrazone-ethyl applied at 0.111 kg ai ha$^{-1}$ and the untreated control at 4, 24, and 48 hours after treatment in experiments 1 and 2. All data were subjected to ANOVA and means were separated using Fisher's protected LSD range test ($P$=0.05). No differences in moss injury or dry weight at 8 WAT were observed, regardless of carfentrazone-ethyl dose in either experiment. These results suggest the rate range for the dose response curve may not be low enough and/or the methodology used to evaluate moss recovery need adjusted.

'CODY' BUFFALOGRASS TOLERANCE TO COMBINATION POSTEMERGENT HERBICIDES. Jared A. Hoyle*; Kansas State University, Manhattan, KS (143)

Options for sedge, broadleaf, and grass weed control in Buffalograss [*Buchloe dactyloides (Nutt.) Engelm.*] are limited and application of traditional herbicides has resulted in unacceptable buffalograss injury. Experiments were conducted in 2013 at the John C. Pair Horticulture Center in Haysville, KS to evaluate 'Cody' buffalograss tolerance to various broad-spectrum postemergent herbicides. 'Cody' buffalograss was maintained at 7.6 cm and irrigated as needed to prevent turfgrass decline throughout the experiment. Soil was a Waldeck fine sandy loam (Coarse-loamy, mixed, superactive, thermic Fluvaquentic Haplustolls). Not all herbicides used in this study are labeled for use on buffalograss. Rates of herbicides were either maximum labeled rate or maximum labeled rate for other warm-season turfgrasses. Herbicide treatments included thiencarbazone (0.03 kg ha$^{-1}$) + iodosulfuron (0.007 kg ha$^{-1}$) + dicamba (0.2 kg ha$^{-1}$) [Celsius], flazasulfuron (0.09 kg ha$^{-1}$) [Katana], quinclorac (0.87 kg ha$^{-1}$) + sulfentrazone (0.07 kg ha$^{-1}$) + 2,4-D (1.0 kg ha$^{-1}$) + dicamba (0.1 kg ha$^{-1}$) [$Q_4$Plus], carfentrazone (0.03 kg ha$^{-1}$) + 2,4-D (1.0 kg ha$^{-1}$) + Mecoprop (0.32 kg ha$^{-1}$) + dicamba (0.1 kg ha$^{-1}$) [Speed Zone], sulfentrazone (0.03 kg ha$^{-1}$) + 2,4-D (0.75 kg ha$^{-1}$) + Mecoprop (0.27 kg ha$^{-1}$) + dicamba (0.1 kg ha$^{-1}$) [Surge], 2,4-D (1.0 kg ha$^{-1}$) + MCPA (0.3 kg ha$^{-1}$) + dicamba (0.1 kg ha$^{-1}$) [Trimec Classic], triclopyr (0.17 kg ha$^{-1}$) + sulfentrazone (0.02 kg ha$^{-1}$) + 2,4-D (0.6 kg ha$^{-1}$) + dicamba (0.07 kg ha$^{-1}$) [T-Zone], quinclorac (0.8 kg ha$^{-1}$) [Drive XLR8], MCPA (1.1 kg ha$^{-1}$) + fluroxypyr (0.11 kg ha$^{-1}$) + triclopyr (0.11 kg ha$^{-1}$) [Battleship III], 2,4-D (0.9 kg ha$^{-1}$) + MCPA (0.25 kg ha$^{-1}$) + dicamba (0.08 kg ha$^{-1}$) [EndRun], sulfentrazone (0.4 kg ha$^{-1}$) + quinclorac (1.2 kg ha$^{-1}$) [Solitare], sulfentrazone (0.4 kg ha$^{-1}$) [Dismiss], carfentrazone (0.03 kg ha$^{-1}$) [QuickSilver], sulfentrazone (0.4 kg ha$^{-1}$) + metsulfuron (0.04 kg ha$^{-1}$) [Blindside], and carfentrazone (0.05 kg ha$^{-1}$) + quinclorac (0.85 kg ha$^{-1}$) [SquareOne]. An untreated check was included for comparison. Plots were treated with herbicides on 1 July 2013. Experimental design was a randomized complete block with four replications and individual plot size of 1.5 by 1.5 m. Herbicides were applied in 374 L ha$^{-1}$ water at 275 kPa with a $CO_2$ pressurized boom sprayer with XR8004VS flat-fan nozzles. Buffalograss phytotoxicity (0 to100%, where 0%=no phytotoxicity), turfgrass color (1 to 9), quality (1 to 9), and Normalized Digital Vegetation Index (NDVI) (0 to 1) were collected 0, 3, 7, 14, 28, 60, and 90 days after treatment (DAT). All data was analyzed using SAS (SAS Institute, Inc.) and means were separated according to Fisher's Protected LSD at $\alpha \leq 0.05$ significance level. No buffalograss injury was observed 7 DAT with Katana or QuickSilver. Slight buffalograss phytotoxicity (0 to10%) was observed 7 DAT on research plots treated with Celsius, $Q_4$Plus, Surge, Drive XLR8, Solitare, Dismiss, Blindside, and SquareOne. Applications of Speed Zone, Trimec Classic, T-Zone, Battleship and EndRun resulted in > 14% buffalograss phytotoxicity. By 28 DAT all herbicide treatments excluding SpeedZone (< 10%) and T-Zone (< 5%), resulted in no buffalograss phytotoxicity. Additional studies are underway evaluating 'Bowie', 'Legacy', '609' and 'Cody' buffalograss herbicide tolerance in both greenhouse and field settings.

INVESTIGATING *POA ANNUA* BIOTYPES COLLECTED FROM GOLF GREENS: GREENHOUSE EVALUATIONS. Alexandra P. Williams*, Michael Barrett, David W. Williams; University of Kentucky, Lexington, KY (144)

*Poa annua* patches on golf course greens, which may represent different biotypes, are commonly observed to differ in regards to color, texture, growth rate, and number of seed heads. It is not known whether these visual differences are promoted by management strategies and/or whether morphologically diverse *Poa annua* plants respond differentially to control programs. We conducted a greenhouse study to examine whether visually different *Poa annua* phenotypes responded differently to chemical treatments. *Poa annua* plants were collected in 2011 from greens at the Lexington Country Club and the University Club of Kentucky, both located in Fayette County Kentucky, and grown in a greenhouse. The plants were collected based on their having one of two appearances while being on the same green: 1. dark green, with few to no flower heads (“dark” biotype) or 2. light green, with numerous flower heads ("light" biotype). Treatments were as follows: paclobutrazol (270 g a.i./ha applied every 3 weeks); flurprimidol (490 g a.i./ha applied every 3 weeks); bispyribac-sodium (25 g a.i./ha applied once at the beginning and the end of the study); and amicarbazone (49 g a.i./ha applied weekly for the first 4 weeks). The experiment was repeated with the same plants in 2011 and 2012. Weekly clipping weights and quality ratings were recorded. In 2011, paclobutrazol, flurprimidol, and amicarbazone reduced the clipping weights of only the “dark” biotypes while bispyribac-sodium reduced the clipping weights of only the “light” biotypes. The only treatment that demonstrated quality variability was flurprimidol where the “light” biotypes collected from the Lexington Country Club had a lower quality rating than the “dark” and the “dark” biotypes from the University Club had a lower quality rating than the “light.” In 2012, with the same plant material, the only two differences observed were lower clipping weights overall from the biotypes from the Lexington Country Club compared to the University Club and lower clipping weights overall with the “dark” compared to the “light” biotypes. These results demonstrate the potential for different responses between *Poa annua* biotypes to PGRs and herbicides and that these differences, like all things about *Poa annua*, may be complex.

TOLERANCE OF RED RASPBERRY TO CLOPYRALID APPLIED PRE-HARVEST, POST-HARVEST, EARLY- AND LATE-FALL. Constanza Echaiz, Doug Doohan*; The Ohio State University, Wooster, OH (145)

Inadequate weed control is a major factor limiting profitability of red raspberry in Ohio. Clopyralid is an auxin-type herbicide that provides very good Canada thistle (*Cirsium arvense*) control. Tolerance of red raspberry to clopyralid was evaluated in two field experiments conducted at Wooster, Ohio during 2010 and 2011. The herbicide was applied at 0.105 and 0.210 kg ae ha$^{-1}$ pre-harvest in late spring (June), post harvest (August), early fall (September) and late fall (November). Crop injury symptom associated with all applications timings was slight chlorosis (<10%). Interaction between timing and rate was evident because pre and post harvest applications had higher damage compared with applications in September and November. Applications in pre harvest and post harvest resulted in damage between 8 - 26%, compared with 0% resulting from applications made in September or November. Raspberry response to clopyralid rate was consistent across application timings. Raspberry plants recovered from clopyralid-induced injury and a yield affect was not detected. Our results indicate that clopyralid applied after harvest is safe to be used in established raspberry to control Canada thistle.

EVALUATION OF SEASON-LONG WEED MANAGEMENT OPTIONS IN POTATO. Jed Colquhoun*, Daniel Heider, Richard Rittmeyer; University of Wisconsin, Madison, WI (146)

While early-season weed control is relatively feasible in potato production with currently registered herbicides used in combination with tillage in the form of crop hilling and rapid crop canopy closure, late-season weed control is challenging and often results in harvest difficulty and weed seed production. With this in mind, the objectives of these potato studies were to: 1) evaluate candidate herbicides in potatoes that would expand available modes of action and provide season-long weed control; and, 2) evaluate hairy nightshade (*Solanum sarrachoides*) control with herbicides used in potatoes and common rotational crops in an effort to reduce the weed seedbank. A series of replicated studies were conducted in 2011 and 2012 in Hancock, WI. Efforts to expand registered herbicide options in potato focused on mesotrione, saflufenacil, cloransulam-methyl and pyroxasulfone applied pre-emergence alone and in combination with s-metolachlor for enhanced grass control. ‘Russet Burbank’ potatoes were grown with conventional practices other than weed control. In general, potato crop tolerance to these herbicides was excellent (less than 5% injury at all rating dates) with the exception of the tank-mix combination of s-metolachlor and mesotrione, which caused significant early-season injury in 2011. Cool, wet weather around the time of herbicide application may have exacerbated this injury compared to 2012. Hairy nightshade control, and in fact general weed control, was excellent when the non-registered herbicides were combined with s-metolachlor. Total potato tuber yield was similar to the industry standard program (s-metolachlor plus metribuzin pre-emergence) in both 2011 and 2012. Hairy nightshade has become particularly problematic in recent years in potatoes and common rotational crops, such as peas and snap beans, where crop contamination by nightshade berries is not tolerated. In 2012, a non-crop preliminary study was conducted to refine hairy nightshade control with existing post-emergent tools used in potatoes and rotational crops. Complete hairy nightshade control was observed where mesotrione, linuron, glyphosate or imazamox were applied. Rimsulfuron and saflufenacil injured hairy nightshade top growth, but the weeds re-sprouted from the base and recovered. Bentazon, 2,4-D and tembotrione failed to control hairy nightshade, and the plants flowered within 3 weeks of application.

## EFFECT OF SIMULATED GLYPHOSATE DRIFT TO RUSSET POTATO CULTIVARS GROWN FOR SEED PRODUCTION. Harlene M. Hatterman-Valenti*, Collin Auwarter; North Dakota State University, Fargo, ND (147)

Field research was conducted at the Northern Plains Potato Grower's Association irrigation research site near Inkster, ND to evaluate potato seed injury from simulated glyphosate drift to mother plants at the tuber initiation (TI), early tuber bulking (EB), and late tuber bulking stage (LB) for four russet potato cultivars: Russet Burbank, Umatilla, Ranger Russet and Bannock. Glyphosate was applied the previous year at rates one-half, one-quarter, and one-eighth the lowest labeled small grain pre-harvest rate of 0.38 lb ae/A. Seed pieces were planted on June 8. Potato stand counts were recorded mid-July. Plots were harvested mid-October and graded shortly after harvest. In general, total and marketable yield were related to plant stands. Ranger Russet seed showed the least injury when mother plants received glyphosate applications the previous year. No stand reductions or yield reductions occurred regardless of the glyphosate rate or application timing compared to non-treated seed. Bannock was the most injured cultivar. Seed from mother plants that received the highest glyphosate rate had reduced plant stands compared to the non-treated regardless of the application timing. Tuber number was reduced when mother plants received 0.19 or 0.1 lb/A at EB or 0.19 lb/A at LB. Marketable and total yield mimicked plant stand data except seed from mother plants that received 0.1 lb /A at EB, which also had reduced yields (54 and 49%, respectively) compared to non-treated seed. Russet Burbank and Umatilla seed from mother plants that had received a sub-lethal glyphosate application were intermediate in response. Further experiments will be conducted to evaluate Ranger Russet sensitivity to glyphosate. However, initial results suggest that Ranger Russet may be used to reduce glyphosate drift injury to potato.

## A COMPARISON OF SYNERGISTIC EFFECTS OF GLYPHOSATE AND BROMOXYNIL DRIFT WITH IN-CROP HERBICIDES IN TOMATO. Darren Robinson*, Kristen E. McNaughton, Peter H. Sikkema; University of Guelph-Ridgetown, Ridgetown, ON (148)

Field studies were conducted in Ridgetown, Ontario from 2008-2010 on processing tomato (*Solanum lycopersicum* L.) to determine if various drift rates of either glyphosate or bromoxynil followed by (fb) an in-crop 250 g ai ha$^{-1}$ metribuzin application would result in cumulative herbicide stress. A transient synergistic interaction was observed when 22.5 g ae ha$^{-1}$ glyphosate was fb metribuzin , however by 28 days after the metribuzin application (DAT-B) all interactions were additive. Additionally additive interactions were identified for all dry biomass and yield ratings when 45, 90, and 180 g ae ha$^{-1}$ glyphosate was followed by metribuzin. However, a drift rate of 22.5 g ae ha$^{-1}$ glyphosate (2.5% of the recommended glyphosate field rate) caused a 23% decrease in red tomato yield. Simulated drift rates of 8.5, 17, and 34 g ai ha$^{-1}$ bromoxynil fb metribuzin had transient synergistic responses at the 7 DAT-B injury rating but by the 28 DAT-B rating all interactions were additive. A synergistic interaction observed during initial visible injury ratings persisted to yield when 68 g ai ha$^{-1}$ bromoxynil (20% of the recommended bromoxynil field rate) was fb metribuzin. At yield, 50 T ha$^{-1}$ of red tomato was expected, based on Colby's equation, but only 36 T ha$^{-1}$ was observed. This finding indicates that a cumulative herbicide interaction can occur even if the various herbicides are applied up to 4 days apart.

SYMPOSIUM INTRODUCTION. Vince M. Davis*; University of Wisconsin-Madison, Madison, WI (149)

The ability to effectively communicate requires skills that constantly need refreshed and enhanced. That is especially true in the fast paced environment that includes new computer technologies. This is a symposium designed to address important elements of Extension education by exploring new and alternative ways to package, and deliver our message to clentele.

GETTING GROWERS TO GO DIGITAL: THE POWER OF A POSITIVE USER EXPERIENCE. Brian McCornack*; Kansas State University, Manhattan, KS (150)

Establishing a strong, competitive online presence is an increasingly important activity for those with Extension responsibilities. It is imperative that online resources save growers from getting lost in a sea of misinformation and redirect stakeholders away from outdated recommendations resulting from general web searches. An innovative approach for online delivery of resources is the development of mobile-friendly decision support systems. Here, we document a case study system (my.iwheat.org) and its design, which is focused on directing wheat stakeholders to management information when and where they need it. For example, one of tools that will be discussed includes the Pest Sampler, which can be used to make treatment decisions for greenbugs in winter wheat using an automated version of a sampling plan but built for mobile devices. Acceptance of such technologies among stakeholders (growers, consultants) will depend on the initial experience and traditional interactions with Extension personnel to properly diffuse technology among growers. Results from our survey show that web-based sampling plans can impact stakeholders and the decisions they make. Specifically, participants of a training event showed an increased willingness to incorporate sampling plans in their management decisions and were more likely to share this data using the web-based form. This exercise demonstrated the importance of a stakeholder’s experience with a web-based application for increased adoption of Extension-related management tools.

YOU TUBE, SOCIAL MEDIA, GOOGLE TOOLS, ETC...EXTENSION TODAY@#MSUWEEDSCIENCE. Erin C. Hill*; Michigan State University, East Lansing, MI (151)

We have come a long way over the past decade. What began with reporting information on simple websites has advanced to a myriad of web-based communication options, creating limitless possibilities for new forms of extension outreach. At Michigan State University we have experimented with various outreach tools including blogging, YouTube, Facebook, QR codes, and more. When it comes determining the effectiveness of these measures we have relied on the insights provided by the various media outlets and Google Analytics. For us, Google Analytics has become a regular form of support in applying for and reporting on grants. During this half hour presentation I will demonstrate some of the trials and tribulations I have experienced with these platforms for both our group weed science website, MSUweeds.com, and the Midwest Cover Crop website, MCCC.msu.edu.

THE NEBRASKA WEED GUIDE: AN INTERACTIVE EXPERIENCE. Lowell Sandell*[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (152)

Migrating extension education materials to dynamic web-based platforms is important to engage traditional and new audiences. UNL weed scientists have developed two web and smart phone based applications to bring weed control and application technology information to the public in an electronic format. The goal of this effort was to create sortable herbicide efficacy ratings for many common weeds along with use recommendations, weed photos and biological information and label links. The application provides information for corn, soybeans, wheat, sorghum, and alfalfa grown in Nebraska. Herbicide efficacy ratings and use recommendations are stored in a MSSQL database. Users access the information through a Flash interface which uses Adobe ColdFusion to dynamically populate the tables with database information. The application allows users to 1) drag the weed columns in any order by clicking, holding, and dragging the column header left or right to the desired location, 2) click once on the weed column header to re-order the herbicide list from highest to lowest efficacy, 3) click on the herbicide name to view detailed information with use recommendations and a direct link to the label at CDMS.net, and 4) click on the camera icon in the weed column header to view identification photos and additional information about each weed species. Utilizing similar software and approaches, an application to dynamically display spray pattern distribution data in a comparative online format is being developed for public use. This application can be used to demonstrate principles of spray applications. A user can adjust variables such as nozzle selection, application pressure and pesticide solution to assess the impact on spray droplet size.

DEVELOPMENT OF THE NDSU PEST MANAGEMENT APP. Angela J. Kazmierczak*; North Dakota State University, Fargo, ND (153)

Information dissemination has shifted from printed material to electronic media formats that allow for data to be dynamic and searchable. The NDSU Pest Management application was designed around this concept. The application is for devices to access mobile versions of the North Dakota Weed Control, Fungicide, and Insect Management Guides. Information can be updated quickly as changes occur. Pest control information for seven crops will be included in the app: corn, dry bean, potato, small grains, soybean, sugarbeet, and sunflower. Pictures of the pests will be included as an identification tool. Choosing a pest name will take a user through a series of decisions to reach a management option. Several features were added that were specific to the Weed Guide that include crop rotation restrictions, herbicide effectiveness, and rainfast information. General information paragraphs from the guides and resources are included on a tab for users to seek more detailed information. The objective in app design was to develop a framework that would allow for expansion of the database, yet keeping the system user friendly and manageable for updating information.

#ETIQUETTE: SOCIAL MEDIA BMP'S. Dawn Refsell*; Valent USA, Columbia, MO (154)

Everyone has their own personal brand. It is not necessarily how you perceive others, but also how they perceive you. In the past, your brand was defined by your appearance, actions, thoughts, and words. None of this has changed, but what has changed is where your brand is present, i.e. your online presence. The presence of Twitter, Facebook, LinkedIn, Google+, blogs, Spotify, Pinterest, etc. in daily conversation and activities only amplifies the role of social media in defining who you are. Your online presence can typically be defined by three areas, 1) identity, 2) feelings, and 3) behavior residue. Your identity is simply anything you say, do, or show. Feelings are typically associated with family, photos, gifts, the music crooning from your IPod, thank you’s, accolades, and other things tied to emotions. Finally, behavior residue is simply the consequences of your actions or lack thereof. Examples would be photos from last Friday night, the freshness of lipstick, or the organization level of your notes, room, or desk. All of these define your personality even though you may not plan for them to do so. Here are my thoughts on avoiding social media blunders:
1) Avoid politics and controversial topics. If you don’t have anything good to say, don’t say it at all. Would you say that in front of your mom? In a job interview? 2) Keep it civil. Avoid sarcasm, cliff hanger posts, insults, tirades, name-calling, or anything to make you appear bigger or better or bitter towards something else. Take the high road, just ignore them. Do not let people get under your skin. 3) Be polite. In some cases, it is best to just say thank you and move on. Everyone is entitled to their own opinion, but realize that they should have kept it personal or to themselves. 4) If you must criticize, only attack the argument or idea via science and fact. Do not attack the person’s intelligence or personality. 5) Regulate your content. Your online presence is what you have defined, own it. Determine who influences you, or what you want your online persona to influence. Your college buddies or your future employer? Do not post anything that you would not want your nieces, nephews, parents, advisor, or potential employer to see.
Graduate students are surrounded by an environment of intelligent, ambitious people. Social media is now a part of professionalism. Take ownership and control for everything you say, where you are seen, and how you portray yourself, your friends, your family, your colleagues, your institution, and your current or potential employer. Facebook is the largest social network available, with the objective of showing you as having a fun, successful online persona. In reality, Facebook may be a land of envy. You may be on the receiving or giving end of this spectrum. When using Facebook, remember who can see your profile. The best thing you can do is to keep your profile private. Utilize filters to limit what others can do such as posting to your wall, tagging you in photos and opinions. You are in control of your Facebook profile- if there is anything in question; delete it, such as likes, pictures, favorites, etc. Define how you use Facebook- is it for social networking or professional networking? Tailor your profile to fit your objective. The same is true for a LinkedIn account. Within LinkedIn, build a community and cultivate relationships that enrich your scholarship and open opportunities for employment. Remember however, these relationships in many cases must withstand a one-on-one meeting, not just an online one. Twitter is a means of participating in public conversations within the philosophic community, but where do you draw the line? Consider the value in what you are sharing. A graduate student or academic must consider their work is actually that of the institution they are at. Businesses typically think of employees as extension of their companies and brands. Simply, think before you tweet. If you do have a twitter account, be

professional. It's a part of your social presence - use your real name. Maintenance of a blog account can be seen as indolent or unprofessional. This is especially true for graduate students - shouldn't you be writing or working on your experiments or better yet, statistics? The desire to have a blog may be personal, not work related. If that is the case, put an anonymous moniker to your blog and put your name to something peer reviewed. In conclusion, you define your online presence. Take control and maintain control of it. Keep the best years of your life first hand, not through a lens/monitor, or behind a keyboard.

INCREASE THE IMPACT OF YOUR PROGRAMS THROUGH BRANDING AND COMMUNICATIONS. Karen Pfautsch*; OsbornBarr, St.Louis, MO (155)

Farmers, like all consumers, are bombarded with messages daily asking them to do something. In our industry, we are fortunate that most of our messages actually benefit the farmer, but it's still not easy to make sure what we communicate is actually seen and heard. There are many factors that go into a successful communications effort, but one path begins with a strong brand. In the world of weeds, university extension weed scientists, herbicide providers and commodity groups have come together to address herbicide resistance with a united, branded message – Take Action. We'll discuss what the Take Action brand adds to many years of outreach on herbicide resistance, but more importantly, we'll focus on how we can apply lessons from Take Action and successful consumer brands to increase the impact of our own programs.

CROP RESPONSE TO DICAMBA APPLICATIONS ON SOYBEAN EVENT MON 87708. Paul Feng*[1], Cindy L. Arnevik[1], Joe Cordes[2], Mindy Devries[3], Mark Lubbers[4], Debi Herren[2], Radha Mohanty[1]; [1]Monsanto Company, St. Louis, MO, [2]Monsanto Company, Jerseyville, IL, [3]Monsanto Company, Huxley, IA, [4]Monsanto Company, Witchita, KS (156)

The soybean event MON 87708 has been engineered to provide tolerance to both glyphosate and dicamba, and is in development for commercialization as Roundup Ready® 2 Xtend soybean. The mechanism for dicamba tolerance was achieved via enzyme deactivation to the non-herbicidal 3,6-dichloro salicylic acid (DCSA). Event MON 87708 has been tested since 2007 and has consistently demonstrated excellent crop safety to Pre- and Post-emergent applications of dicamba. With expanded field testing, observations were made in 2011 by academic as well as internal researchers of a transient response to dicamba under certain environmental conditions. Subsequent greenhouse and field trials were established to further characterize this response. Results from the greenhouse and field studies as well as yield data from the 2012 and 2013 seasons will be presented.

DICAMBA FORMULATION ADVANCEMENTS. Joseph J. Sandbrink*, Alison Macinnes, John W. Hemminghaus, Jeff N. Travers, Simone Seifert-Higgins, Susan E. Curvey; Monsanto Company, St. Louis, MO (157)

Monsanto Company is developing formulations containing dicamba for use in the Roundup Ready® Xtend™ Crop System. A premix formulation containing diglycolamine (DGA) dicamba and monoethanolamine (MEA) glyphosate delivering a 2 to 1 ratio of glyphosate to dicamba has been developed. A dicamba standalone formulation based on the DGA dicamba salt has also been developed. Both formulations contain proprietary VaporGrip™ technology that reduces the potential of dicamba volatility compared to dicamba formulations that do not. These formulations show commercially acceptable physical/chemical properties consistent with Roundup® agricultural herbicide formulations and are pending regulatory approval. Although volatility is a small contributor to potential off-target movement, this often remains a concern from growers and applicators as a legacy from the dimethylamine (DMA) salt launched in the 1960s. The DGA salt of dicamba consistently shows lower volatility and this can be reduced further by using VaporGrip™ technology. Spray drift and tank contamination are the main contributors to potential off-target movement. These can be decreased significantly through appropriate application practices and proper tank clean out. Application requirements for both have been developed as part of the Roundup Ready® Xtend™ Crop System to increase on-target applications. Certain statements contained in this presentation are **"forward-looking statements,"** such as statements concerning the company's anticipated financial results, current and future product performance, regulatory approvals, business and financial plans and other non-historical facts. These statements are based on current expectations and currently available information. However, since these statements are based on factors that involve risks and uncertainties, the company's actual performance and results may differ materially from those described or implied by such forward-looking statements. Factors that could cause or contribute to such differences include, among others: continued competition in seeds, traits and agricultural chemicals; the company's exposure to various contingencies, including those related to intellectual property protection, regulatory compliance and the speed with which approvals are received, and public acceptance of biotechnology products; the success of the company's research and development activities; the outcomes of major lawsuits and the previously announced SEC investigation; developments related to foreign currencies and economies; successful operation of recent acquisitions; fluctuations in commodity prices; compliance with regulations affecting our manufacturing; the accuracy of the company's estimates related to distribution inventory levels; the company's ability to fund its short-term financing needs and to obtain payment for the products that it sells; the effect of weather conditions, natural disasters and accidents on the agriculture business or the company's facilities; and other risks and factors detailed in the company's most recent periodic report to the SEC. Undue reliance should not be placed on these forward-looking statements, which are current only as of the date of this presentation. The company disclaims any current intention or obligation to update any forward-looking statements or any of the factors that may affect actual results.

PERFORMANCE OF ENGENIA™ HERBICIDE PROGRAMS IN DICAMBA TOLERANT SOYBEANS. Dustin Lewis*[1], John Frihauf[2], Walter Thomas[2], Steven Bowe[2], Luke L. Bozeman[2]; [1]BASF Corporation, Seymour, IL, [2]BASF Corporation, Research Triangle Park, NC (158)

Engenia™ herbicide is a new experimental formulation (EPA approval pending) based on the BAPMA (N, N-Bis-(aminopropyl) methylamine) form of dicamba. Research indicates that Engenia herbicide will reduce the secondary loss potential of dicamba beyond the previous improvement achieved with Clarity® herbicide over Banvel® herbicide. The use of Engenia herbicide in dicamba tolerant soybeans will offer growers a new tool to effectively manage difficult to control broadleaf weeds such as those resistant to EPSPS, triazine, ALS, and PPO herbicides. Weed management programs should be designed to take advantage of dicamba's postemergence and moderate residual activity. Combining dicamba with preemergence herbicides preplant provides burndown with critical broad spectrum early season residual control. BASF field trials have demonstrated that postemergence use of dicamba with glyphosate and other effective herbicides following a preemergence or preplant residual herbicide program often provides the most consistent and effective control. Optimum postemergence control is obtained when Engenia is applied to small weeds no larger than four inches. Residual herbicides may be needed with postemergence applications in locations where multiple weed flushes occur. Integration of weed management strategies that combine herbicide, cultural, and mechanical control techniques such as diverse herbicide programs with multiple effective mechanisms of action, crop rotation, and sanitation are critical to effectively manage herbicide resistant weeds and protect the utility of dicamba-tolerant cropping systems.

STEWARDSHIP OF ENGENIA™ HERBICIDE. Shane Hennigh*[1], Walter Thomas[2], Steven Bowe[2], Luke L. Bozeman[2]; [1]BASF Corporation, Story City, IA, [2]BASF Corporation, Research Triangle Park, NC (159)

New weed control options are needed to manage herbicide resistant weeds that are limiting control tactics and cropping options in some areas. Dicamba tolerant soybean and cotton will enable the postemergence in crop use of dicamba to manage problematic weeds with an additional herbicide site-of-action. In addition, dicamba tolerant cropping systems will allow for dicamba application preemergence without a planting interval restriction. Engenia™ herbicide, currently not registered by the US EPA, is an advanced formulation based on BAPMA (N, N-Bis-(aminopropyl) methylamine) dicamba salt that minimizes secondary loss of dicamba. Combined with this formulation innovation, a comprehensive stewardship strategy will be implemented to focus on effective weed control, weed resistance management, and maximizing on-target application. Engenia herbicide should be integrated as a component of a grower's weed control program along with other cultural, mechanical, and chemical control methods. A robust herbicide program uses sequential and/or tank mixtures of herbicides that have multiple effective sites of action on target weeds. Likewise, Engenia should complement current programs adding an additional effective site of action for broadleaf weed control. Over several years of testing, the most effective soybean weed control programs have utilized preemergence followed by postemergence applications of herbicides like Optill® PRO followed Engenia plus glyphosate. Many parameters related to equipment setup and environmental conditions during application should be considered to maximize on-target deposition. Nozzle selection offers the opportunity to dramatically reduce the potential for spray drift. Research shows that venturi-type nozzle technology can significantly reduce drift potential. Other application parameters that should be considered include travel speed, boom height, application volume, use of a deposition aid, and proximity to sensitive crops. BASF has initiated the 'On Target Spray Academy' training program to educate applicators on best application practices. The combination of Engenia and dicamba tolerant crops plus stewardship will provide growers with an effective system to control increasingly difficult and herbicide-resistant broadleaf weeds.

ENLIST™ SOYBEAN TOLERANCE AND WEED CONTROL WITH PRE FOLLOWED BY POST HERBICIDE PROGRAMS. David C. Ruen*[1], Jeff M. Ellis[2], David M. Simpson[3], Jonathan A. Huff[3]; [1]Dow AgroSciences, Lanesboro, MN, [2]Dow AgroSciences, Smithville, MO, [3]Dow AgroSciences, Indianapolis, IN (160)

The Enlist™ Weed Control system is being developed in multiple crops and includes Enlist™ soybean and Enlist E3™ soybean. Enlist is a weed control system composed of new herbicide-tolerant traits and a new herbicide solution, Enlist Duo™ herbicide. Regulatory approvals are pending for components of the Enlist system. Enlist soybean when stacked with glyphosate-tolerant traits, such as Roundup Ready 2 Yield, and Enlist E3 soybean will provide tolerance to glyphosate, glufsosinate and 2,4-D. Integrating multiple modes of action herbicides into a preemergence followed by postemergence weed control program provides consistent, highly effective control and helps prevent the onset of herbicide- resistant weeds. A total of 22 studies were conducted in 2013 in the U.S. to evaluate the weed control delivered by a systems approach composed of PRE followed by POST herbicide applications in Enlist E3 soybeans. PRE foundation treatments consisted of cloransulam + sulfentrazone, flumioxazin + cloransulam, flumioxazin + chlorimuron ethyl or *S*-metolachlor + fomesafen herbicide products . Postemergence treatments were Enlist Duo (2,4-D choline + glyphosate DMA) at 1640 and 2185 g ae/ha, glufosinate at 542 g ae/ha, 2,4-D choline + glufosinate at 800 + 542 and 1065 + 542 g ae/ha, and glyphosate at 1120 g ae/ha applied approximately 30 days after planting. PRE applications of cloransulam + sulfentrazone or flumioxazin + cloransulam followed by Enlist Duo at 1640 or 2185 g ae/ha or 2,4-D choline + glufosinate at 800 +542 or 1065 + 542 g ae/ha provided greater than 95% control of CHEAL, IPOSS and AMAPA and glyphosate resistant AMATA, AMBEL and AMBTR. Enlist Duo and 2,4-D + glufosinate treatments resulted in less than 3% visual soybean injury at 14 days after application. ™Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow. Regulatory approvals are pending for the Enlist herbicide solution and crops containing Enlist herbicide tolerance traits. The information presented here is not an offer for sale. Always read and follow label directions. ©2013 Dow AgroSciences LLC Enlist E3™ soybeans are being jointly developed by Dow AgroSciences and MS Technologies.

UNIVERSITY EVALUATION OF ISOXAFLUTOLE WEED MANAGEMENT PROGRAMS IN HPPD TOLERANT SOYBEAN SYSTEM. Michael L. Weber*; Bayer CropScience, Indianola, IA (161)

*NO ABSTRACT SUBMITTED*

ENHANCED WEED MANAGEMENT SOLUTIONS WITH MGI HERBICIDE-TOLERANT SOYBEANS. Dain E. Bruns*[1], Rakesh Jain[2], Thomas H. Beckett[2], Brian L. Wilkinson[2], Brian Erdahl[2]; [1]Syngenta, Marysville, OH, [2]Syngenta, Greensboro, NC (162)

Field trials were conducted in 2012 and 2013 to evaluate mesotrione-based weed control programs in MGI herbicide-tolerant soybeans stacked with glyphosate tolerance. These multiple mode-of-action herbicide tolerant soybeans enable the use of mesotrione and isoxaflutole pre- and post-emergence in addition to glyphosate and glufosinate-ammonium post-emergence. Several mesotrione-based herbicide programs provided control of key weed species, including glyphosate resistant populations. The most successful and consistent weed control was achieved with two-pass programs that included pre-emergence residual herbicides and multiple, overlapping modes of action. These programs were designed to align with HRAC principles of weed resistance management. The use of these chemically diverse and novel programs will offer effective, safe and sustainable weed management options for soybean growers.

## INFLUENCE OF WEED COMPETITION DURATION ON SOYBEAN NUTRIENT ACQUISITION AND GRAIN YIELD CHARACTERISTICS.

Nick T. Harre*[1], Bryan G. Young[1], Scott E. Cully[2], Brett R. Miller[3], Mark Kitt[3], Bryan J. Ulmer[4]; [1]Southern Illinois University, Carbondale, IL, [2]Syngenta, Marion, IL, [3]Syngenta, Minnetonka, MN, [4]Syngenta, Basel, Switzerland (163)

The effectiveness and flexibility provided by glyphosate-resistant soybean diminished the use of soil-residual herbicides and arguably, augmented the potential risk of soybean yield loss from early-season weed competition. The rapid biogeographical spread of herbicide-resistant weeds, especially glyphosate-resistant biotypes, over the past decade has stimulated a resurgent use of soil-residual herbicides in soybean focused towards herbicide resistance management. As new herbicide-resistant soybean technologies continue to be developed, growers may once again abandon the utilization of soil-residual herbicides as a weed management tactic. Thus, given the commercial interest in high yield soybean production, the benefits provided by early-season weed control beyond those of herbicide resistance management must be further characterized. Field experiments were conducted in 2012 and 2013 across four sites throughout southern Illinois to study the influence of early-season weed management strategies on soybean nutrient acquisition, grain yield parameters, and the accumulation of nutrients by broadleaved and grass weeds. Weed removal with a POST application of glyphosate was performed when weeds reached 10, 20, 30, or 45 cm in height. A weed-free treatment utilizing a comprehensive soil residual and POST herbicide program was included to implement a weed-free comparison. Two standard herbicide management strategies were also evaluated for comparison: flumioxazin PRE followed by glyphosate POST and two sequential POST glyphosate applications. Soybean grain yield reductions were observed when weeds were allowed to reach heights of 45 cm and 10 cm in 2012 and 2013, respectively, pooled across sites. In 2013, soybean seed weight was reduced when weeds were not controlled before a height of 10 cm, while a decline in grain oil content occurred when weeds were not controlled before reaching 20 cm. Broadleaved weeds accumulated 28, 17, and 16% more N, P, and K than grass weeds in 2012 and 52, 42, and 61% more N, P, and K in 2013. Interference from 20 cm weeds reduced the accumulation of N, P, Ca, Mg, S, Fe, B, Cu, and Zn by soybean in 2012. These nutrients in addition to K and Mn were reduced in 2013. Therefore, early-season weed management strategies promote a more sustainable approach in soybean production systems as they provide multiple agronomic benefits beyond herbicide resistance management by increasing the nutrient acquisition capacity in soybean and circumventing yield reductions imposed by weed competition.

## NEW RESIDUAL MANAGEMENT SYSTEMS TO ADDRESS HERBICIDE RESISTANT WEEDS IN SOYBEANS.

Dario F. Narvaez*[1], James Whitehead[2], David Feist[3], Keith Miller[4], Dave Downing[5], Brian Ahrens[6]; [1]MANA, Wildwood, MO, [2]MANA, Oxford, MS, [3]MANA, Ft. Collins, CO, [4]MANA, Troy, IL, [5]MANA, Raleigh, NC, [6]MANA, Coralville, IA (164)

With the rapid spreading of glyphosate-resistant weeds plus the lack of development of advanced herbicides with new modes of action (MOAs), growers will have to rely on the MOAs available in currently registered herbicides for the near future. Regardless of the weed management system in place, it is imperative that growers use residual herbicides pre- and/or post-emergence to help manage weed resistance and to protect yield potential. The challenge is to control not only the resistant weed that is present, but also to prevent and/or to lower the selection pressure potential for the emergence of new herbicide-resistant weeds in the field. Therefore, the integration of both soil-residual and non-residual herbicides with multiple modes and sites of action is warranted. MANA has a broad soybean herbicide portfolio and the company has initiated a tank-mix screening program to evaluate potential mixtures that could offer simplified weed control solutions for soybean growers. Through its formulation development and screening program across the soybean production area of the United States, MANA developed two promising mixtures: Torment® and Pummel™ herbicides. The screening program focused on developing a unique premix that offers a complete residual herbicide management system to improve consistency of control and prevent subsequent emergence of glyphosate-resistance during the growing season.

PREEMERGENCE WEED CONTROL IN SOYBEAN WITH CHLORIMURON, FLUMIOXAZIN, AND METRIBUZIN. Kelly A. Barnett*[1], Helen A. Flanigan[2], Kevin L. Hahn[3], Dan Smith[4]; [1]DuPont Crop Protection, Whiteland, IN, [2]DuPont Crop Protection, Greenwood, IN, [3]DuPont Crop Protection, Bloomington, IL, [4]DuPont Crop Protection, Madison, MS (165)

*NO ABSTRACT SUBMITTED*

---

LOW VOLUME DORMANT STEM TREATMENTS FOR EXTENDING THE BRUSH CONTROL SEASON. Pat Burch[1], Travis Roger[2], Ernest S. Flynn*[3]; [1]Dow AgroSciences, Christiansburg, VA, [2]Dow AgroSciences, Charleston, SC, [3]Dow AgroSciences, Ankeny, IA (166)

Dormant stem brush applications can be a useful tool in right-of-way vegetation control. It allows for the brush control season to be extended, reduces vegetation management visibility, allows applications in closer proximity to sensitive sites, keeps brush crews working throughout the season, and can be used to target brush when it's at a manageable height. The purpose of this study was to quantify the efficacy of potential tank mixes with Garlon 4 Ultra herbicide, and to determine the effect of timing on the level of control. Trials were conducted at locations in Arnoldsville, GA, and in Critz, VA. Three treatment levels were used during fall and winter timings: 6% v/v Garlon 4 Ultra + 0.5% v/v Milestone + 2% v/v DYNE-AMIC with and without 0.5% v/v Stalker; and a 5% v/v Garlon 4 Ultra + 0.5% v/v Milestone + 0.5% v/v Stalker + 3.5% v/v HY-GRADE I treatment. All treatments were applied with water as a diluent with a total solution volume of 3.8 liters per 100 stems treated. Red maple, Southern red oak, yellow-poplar, sweetgum, loblolly pine, and black locust ranged in control from 87 to 97%. There was no difference between application dates opening the possibility to treat beginning in the fall before complete leaf drop and continuing through early leafout (up to 25% leaf expansion). There was also no significant difference between tank mixes or adjuvants on these species.

---

CALIBRATION TECHNOLOGY. Robert E. Wolf*; Wolf Consulting & Research LLC, Mahomet, IL (167)

Application technology has taken on a new focus with an emphasis on information technology; much of it aimed at spray droplet size. There are smart phone apps to help applicators make decisions about calibration, nozzle selection, and droplet size (spray quality) requirements. Apps are also available to help in various other aspects of the applications process including tank mixing guides to help reduce the incidence of the problems associated with improper tank mixing order. Some apps are capable of creating a spray log to improve record keeping. Compass and wind meter attachments are becoming available so that smart phones can be used as wind speed and direction indicators in the field. There are also new hardware/electronic items coming into the sprayer market to assist in calibration and droplet size monitoring. TeeJet has introduced a new rate controller that can display a pressure-based droplet size during the application. They also have a specific drop size monitor for that same purpose and recently introduced a flow monitor that can keep tract of flow from each nozzle during the spray operation. This latest tool will keep operators apprised of any nozzle flow problems that are not readily visible while spraying…ie. behind the sprayer. Capstan has introduced a new version of the pulse width modulation technology that will control flow at each nozzle independently, which will also keep applicators informed of nozzles that are not flowing equally and compensate for speed differences along the length of the boom while the sprayer is turning with the boom on. An electronic calibration tool from Innoquest is available to make sprayer calibration much easier and not as time consuming.

---

THE EFFECTS OF NOZZLES AND DRIFT REDUCTION AGENTS ON DROPLET SIZE DISTRIBUTIONS OF DICAMBA AND GLYPHOSATE MIXTURES. Thomas B. Orr*[1], Kirk B. Remund[1], Jeff N. Travers[1], Joy L. Honegger[1], Andrew Hewitt[2]; [1]Monsanto Company, St. Louis, MO, [2]University of Nebraska-Lincoln, North Platte, NE (168)

A series of wind tunnels studies were conducted to determine the effects of nozzle selection, nozzle, orifice size, spray pressure, and formulation composition on spray droplet distributions of dicamba/glyphosate mixes. The first study was conducted at the University of Queensland, Australia in 2012 and included 14 nozzles, three orifice sizes for each nozzle

(03, 04, and 05), two spray pressures, and a total of four dicamba/glyphosate mixes, including two tank mixes (TM1, TM2) and two premixes (PM1, PM2). Spray pressures were adjusted to correspond to application volumes of 10 and 15 GPA. Droplet size distributions for all possible combinations of the four factors were measured using a laser in a wind tunnel. The data were statistically analyzed using a full factorial response surface model. The application parameters of nozzle selection and spray pressure had the largest effect on droplet size of the four primary factors evaluated in the model. Percent driftable fines (% volume < 150 µm) was primarily influenced by nozzle and pressure with nozzle selection being the most critical factor for reducing driftable fines. A follow-up study conducted at the University of Queensland in 2013 evaluated the effects of drift reduction agents (DRAs) on droplet size distributions of dicamba/glyphosate mixes using a subset of nozzles evaluated in the 2012 study. The effects of DRAs on droplet size distributions for dicamba/glyphosate mixtures for various nozzles will be presented.

EVALUATING DRIFT REDUCTION TECHNOLOGIES FOR THE CONTROL OF GLYPHOSATE-RESISTANT WATERHEMP USING DICAMBA AND GLYPHOSATE. Robert E. Wolf*[1], Scott M. Bretthauer[2], Matthew Gill[2], Bryan G. Young[3], Greg R. Kruger[4]; [1]Wolf Consulting & Research LLC, Mahomet, IL, [2]University of Illinois, Urbana-Champaign, IL, [3]Southern Illinois University, Carbondale, IL, [4]University of Nebraska-Lincoln, North Platte, NE (169)

This project evaluated the use of drift reduction technologies for the application of glyphosate and dicamba to control glyphosate resistant waterhemp (AMATG). Six nozzle types and two drift reduction adjuvants, as well as no drift reduction adjuvant, were evaluated. To evaluate efficacy, the 18 treatments were used in a field trial on a soybean field with glyphosate resistant AMATG southwest of Dowell, Illinois. Drift potential was evaluated through droplet size measurement conducted in a low speed wind tunnel. Nozzles evaluated were the Turbo TeeJet Induction (TTI11004), Air Induction Extended-Range (AIXR11004), Air Induction Turbo TwinJet (AITTJ60-11004) from Spraying Systems, the Mid Range (MR110-04) from Wilger, the Guardian Air Twin (GAT110-04) from Hypro, and the TurboDrop DualFan (TADF04) from Greenleaf. All nozzles were operated at 331 kPa. The drift reduction adjuvants tested were Interlock (vegetable oil based) at 292 mL/ha and Border EG (guar based with no AMS) at 283 g/379 L. Applications were made with an ATV mounted compressed air sprayer operated at 21 km/h and a spray volume of 94 L/ha; nozzles spacing and height was 51 cm. A glyphosate/dicamba premix (MON 76832 plus MON 10, an AMS replacement) was used in all treatments at 4,676 mL/ha. The treatments were applied in RCBD with 3 replications. Applications were made when weed height was around 15 to 20 cm; control was evaluated at 10 and 21 DAT. There were significant differences among the treatments in controlling waterhemp (AMATG). Extensive rains after treatment and a massive regrowth of the waterhemp made it difficult to fairly assess the 21 DAT data. Numerically, but with no significant differences between the top 3 treatments at 10 DAT, the MR nozzle with Border EG provided the best control at 94%, followed by the MR with no adjuvant at 93% and then the TTI with no adjuvant at 92%. The lowest control at 10 DAT was from the TADF with Border EG at 86%. Evaluations of nozzle and adjuvant factors revealed that the MR nozzle provided significantly better control than the other nozzles. There were no significant differences between the adjuvants evaluated but Interlock provided slightly better control at 90.4% for Interlock versus 89.6% for Border EG; no drift reduction adjuvant provided 91% control. For droplet size, the MR and the GAT had the lowest VMD and the highest percent fines; the TTI had the largest VMD and the lowest percent fines. Border EG increased the VMD decreased the percent fines for all nozzle types. Interlock slightly increased the VMD for some nozzle types but by a much smaller margin; for some nozzle types it slightly reduced the VMD. Interlock reduced the percent fines for all nozzle types, but not as much as Border EG did.

NONIONIC SURFACTANT ADJUVANT WITH OPTIMIZED PHYSICAL AND BIOLOGICAL PROPERTIES FOR HERBICIDE TANK MIXTURES. Gregory J. Lindner*[1], Kevin Penfield[1], Bryan G. Young[2], Marcia Werner[3]; [1]Croda Inc, New Castle, DE, [2]Southern Illinois University, Carbondale, IL, [3]Croda Brasil, Campinas, Brazil (170)

The nonionic surfactant (NIS) adjuvant composition evaluated offers versatility for use in NIS, COC, HSOC, and MSO adjuvants. It is characterized as a liquid with low fluid viscosity offering ready dilution without gel formation and minimal foam generation under most conditions of use. As evaluated, it conforms to CPDA Adjuvant Certification standards. Data on surfactant performance indicates low contact angle signifying desirable wetting properties and spreading coefficient, low surface tension indicating effective performance as a surfactant, low viscosity at a range of temperatures without use of alcohols or glycols, solubility in a selection of oils and across a range of temperatures, and good to excellent dilution performance either "as is" or as an oil adjuvant emulsifier. In mixtures with glyphosate, it did not significantly increase the volume of driftable fine droplets and unlike other adjuvants tested (consistent with the internal standard used as a positive control) it effectively reduced the volume fraction of smaller droplets in most nozzles tested. When evaluated as an adjuvant at 0.25% (v/v) with glyphosate, 2,4-D, or dicamba, equivalent or better control was observed in comparison to NPE-based adjuvants. Saflufenacil control of glyphosate resistant marestail and amaranthus species equivalent to the use of 1.0% (v/v) MSO was achieved at adjuvant use rates between 0.25% and 0.5% (v/v). Based on the results generated, it may be used at lower rates (0.25%-0.5% v/v) in comparison to standard COC or MSO adjuvants (1.0% v/v) to provide equivalent weed control when applied with specific tank mixtures of selective herbicides with glyphosate. Treatment at rates between 0.25% and 0.5% (v/v) in glyphosate combinations with clethodim provided control of volunteer corn, morningglory species, and broadleaf signalgrass equal to a combination of 1.0% (v/v) COC with 0.25% NIS. Use of rates between 0.25% and 0.5% (v/v) with tembotrione and glyphosate provided statistically equivalent control of common waterhemp, morningglory, and velvetleaf when compared to full rates of both MSO (1.0% v/v) and NIS (0.25% v/v). Unlike tembotrione and clethodim, adjuvant use with saflufenacil and glyphosate at rates between 0.25% and 0.5% (v/v) in the presence of 0.42% ammonium sulfate provided less effective control of common waterhemp. Treatments containing saflufenacil and glyphosate provided statistically equivalent control of fall panicum when compared to full rates of both MSO (1.0% v/v) and NIS (0.25% v/v).

## ATOMIZATION OF AGRICULTURAL TANK MIXTURES IN RESPONSE TO A PULSE WIDTH MODULATION (PWM) SPRAY DELIVERY SYSTEM. Lillian C. Magidow*[1], Stephanie Wedryk[1], Donald Penner[2]; [1]Winfield Solutions, St. Paul, MN, [2]Michigan State University, East Lansing, MI (171)

*NO ABSTRACT SUBMITTED*

## MINIMIZING DICAMBA DRIFT WITH IMPROVED HOODED SPRAYERS. Joseph J. Sandbrink*[1], Jeff N. Travers[1], Steve Claussen[2]; [1]Monsanto Company, St. Louis, MO, [2]Willmar, Willmar, MN (172)

Monsanto is currently developing transgenic cotton and soybean varieties capable of tolerating postemergence applications of dicamba. This technology facilitates effective control of many troublesome weed species, including some that have exhibited resistance to glyphosate. There has been historical concern about incidences of off-target deposition with dicamba. Monsanto will require the use of spray nozzles that produce very coarse to ultra coarse spray droplets and other cultural practices in an effort to reduce fine particles and off target movement. In addition to improved nozzle selection to mitigate drift, Willmar Fabrication LLC is developing new and improved broadcast hooded sprayers for use with this technology. In 2013 Monsanto conducted four field trials comparing the Redball™ Gen II Broadcast Spray Hood vs. an identical open spray boom for mitigating dicamba off-target deposition. These trials were conducted in Robinsonville, MS; Scott, MS; Marion, AR and Hawkinsville, GA. Each 12.2 meter MODEL 642 three point broadcast hooded sprayer was equipped with 11004 Turbo TeeJet® Induction Flat Spray nozzles (TTI). An identical MODEL 642 open boom sprayer was also included in the trials for direct comparison. All spray solutions contained glyphosate - 1120 g ae/ha, dicamba - 560 g ae/ha, drift reduction additive (DRA) - 290 g ai/ha, and MON 10 at 4% v/v. Sprayers were calibrated to deliver 93.69-140.53 L/Ha. Each sprayer was attached to a tractor and applications were made to non-dicamba tolerant soybeans at the V3-V4 growth stage. Non-dicamba tolerant soybeans were utilized as a bio-indicator because of their sensitivity to dicamba. Winds were generally perpendicular to the sprayed plot and were less than 16.09 km/h. Visual estimates of plant response and plant heights were collected from each downwind experimental unit at approximately 2 and 4 weeks after treatment. Plant response measurements were taken at incremental distances away from the treated plot for each treatment. The distance that plant response was observed to a 5% level was recorded and the data analyzed. Plant response data were fitted as a function of log(distance) using linear regression. Results averaged across all four sites using the 5% crop response criteria indicated 8.96 meters with the Redball™ Gen II Broadcast Spray Hood vs. 38.5 meters with the open boom sprayer. Using 15% crop response as the criteria results were 3.55 meters with the Redball™ Gen II Broadcast Spray Hood and 17.92 meters with the open boom sprayer. These results suggest that the Redball™ Gen II Broadcast Spray Hood can significantly reduce the off target movement of dicamba when used in combination with Turbo TeeJet® Induction Flat Spray nozzles (TTI).

## METHODS FOR DEACTIVATING DICAMBA SOLUTIONS IN AGRICULTURAL SPRAY EQUIPMENT.

Susan E. Curvey*[1], David A. Morgenstern[1], Jeff N. Travers[1], Joseph J. Sandbrink[1], Ryan J. Rector[2]; [1]Monsanto Company, St. Louis, MO, [2]Monsanto Company, St Louis, MO (173)

Monsanto is preparing to introduce dicamba-tolerant soybeans and cotton. Over the next decade, Monsanto's dicamba tolerant soybean and cotton could be joined in the marketplace by crops tolerant to 2,4-D, isoxaflutole and other herbicides. The multiplicity of traits and herbicides that will be recommended in the field will create challenges for applicators. Ensuring that herbicide residues from the prior spray loads do not injure sensitive crops in subsequent applications will be critical. Stewardship of the dicamba chemistry includes developing a tank-cleaning method based on oxidation of residual dicamba in the spray tank with hydrogen peroxide and iron. This process, known as "Fenton chemistry," will be described in greater detail at the presentation titled; "Simple and Reliable Tank Cleaning" ; Morgenstern et al. Fenton tank cleaning was tested in a series of field trials conducted in 2013, typically on the scale of a few acres. The protocol used three moles of ferrous sulfate per mole of glyphosate and 30 moles of $H_2O_2$ per mole of dicamba. The reaction occurred in the tank with the remaining herbicide solution using a 20-minute treatment time. When the treatment was performed as recommended, the dicamba and glyphosate in the tank was deactivated and spray mixture was found to be crop-safe when applied over dicamba-sensitive soybeans. The Fenton procedure was at least as effective as triple-rinsing and far faster and more convenient. Testing showed that it is critical to know the amount of heel solution to be treated so the appropriate amount of Fenton chemistry can be added to the tank and an internal tank spray nozzle is necessary for proper sidewall cleaning and rinsing. Iron based rust can be dislodged during treatment which will require screens to be cleaned and over flow of foam can be a problem for low volume tanks. Further work is being developed to manage identified issues for potential commercial use.

## SIMPLE AND RELIABLE TANK CLEANING.

David A. Morgenstern*, Ronald J. Brinker, James W. Taylor, James P. Fornango, Jeff N. Travers; Monsanto Company, St. Louis, MO (174)

Monsanto's dicamba-tolerant cropping system will soon be introduced in the US, providing a second mode of action for control of broadleaf weeds that complements the Roundup Ready® trait. Residual dicamba-glyphosate solution remaining in the spray tank could cause crop injury if the next field sprayed is not dicamba-tolerant. In this situation, reliable removal of greater than 99% of the residual dicamba is necessary to ensure crop safety. This removal is typically achieved by triple rinsing the spray tank. While triple rinsing has been proven effective for removing dicamba from spray tanks and hoses, we report an alternative approach in which residual dicamba is deactivated in the spray tank by catalytic oxidation. Hydrogen peroxide catalyzed by iron has been demonstrated to successfully oxidize dicamba and other herbicides in 20 minutes. Accurate knowledge of the volume and composition of the tank "heel" or residual spray solution is absolutely essential for successful removal of dicamba from the sprayer tank and hoses. To demonstrate the effectiveness of the dicamba deactivation, spray mixtures of dicamba and glyphosate were treated with hydrogen peroxide catalyzed by iron; the resultant "hot rinse" was applied over the top of soybeans lacking dicamba tolerance, with excellent crop safety. Iron-peroxide oxidation, known as "Fenton chemistry," is well-known in the waste-treatment community and is a robust and reliable technology for the treatment of lean aqueous waste such as agricultural spray solutions. Hydrogen peroxide is destroyed during the Fenton process, but the iron remains. For a few herbicides, iron can have a small, negative impact on next-load efficacy. We have found that the addition of a small amount of Roundup® ties up the iron and eliminates next-load concerns. Greenhouse results will be presented on the efficacy of the Fenton procedure along with practical considerations for safe and effective application to full-scale field sprayers.

## EFFECT OF WINTER WHEAT COVER CROP RESIDUE ON DRY BEAN DEVELOPMENT AND HARVEST LOSS.

Andrew R. Kniss*[1], Robert Baumgartner[2], David Claypool[1]; [1]University of Wyoming, Laramie, WY, [2]University of Wyoming, Lingle, WY (175)

Harvest loss can be high when direct harvesting dry bean due to pods being set relatively low to the ground compared to other legume crops like soybean. It is possible that increasing the amount of cover crop residue on the soil surface may trigger a shade avoidance response in dry bean and increase pod height. The increased pod height may, in turn, reduce losses when direct harvesting dry bean. A field study was conducted in Wyoming in 2013 to determine the effect of winter wheat cover crop residue on dry bean development, yield, and harvest loss. Winter wheat was seeded over the entire trial area in the autumn of 2012, and three cover crop termination treatments were established in the spring of 2013. Termination of the cover crop occurred on May 11 (23 days before planting, DBP), June 2 (1 DBP), and June 21 (18 days after planting, DAP). On June 19, winter wheat biomass of 172, 1430, and 5053 kg/ha was present in the dry bean crop for the three cover crop termination treatments, respectively. The treatments had a strong effect on many dry bean growth parameters including yield and harvest loss. Where the winter wheat crop was terminated 1 DBP, the height of the lowest bean pod was 0.8 cm compared to 1.5 cm where the cover crop was terminated 23 DBP. Where the cover crop was terminated 18 DAP, the lowest bean pods were, on average, 4.3 cm from the soil. Harvest loss followed a similar pattern, with 2057, 1471, and 130 kg/ha of dry bean left on the soil surface for the 23 DBP, 1 DBP, and 18 DAP treatments, respectively. Although harvest loss was greatly reduced in the high-residue treatment, dry bean yield was reduced 63% due to competition between the winter wheat and dry bean. This research indicates that planting dry bean into cover crop residue can decrease direct harvest loss, but timing of cover crop termination will be critical to the success of this practice.

## BENEFITS AND ECONOMICS OF "THE CRITICAL PERIOD OF COMPETITION" AND "THE ZEROSEED THRESHOLD" WEED MANAGEMENT STRATEGIES FOR TRANSITIONING TO ORGANIC FARMING.

Mohsen Mohseni-Moghadam*[1], Karen Amisi[2], Doug Doohan[3]; [1]OSU-OARDC, Wooster, OH, [2]Grand Valley State University, Allendale, MI, [3]The Ohio State University, Wooster, OH (176)

The best organic farmers rely on diverse opportunities to suppress weed populations throughout the complex rotations that characterize their farming systems. Tactics include the rotation itself, tillage, cultivation, hand-weeding, living and plastic mulches, cover crops, and slashing. We investigated the use of two strategies, the critical period of competition (CP) and the zero-seed threshold (ZT), and the effect of soil amendments (compost and manure) for farmers transitioning from conventional to organic production. We also determined the labor required to implement these weed management strategies. Field experiments were conducted at the Ohio Agricultural Research and Development Center in Wooster, OH. In 2001, a 4-year rotation of wheat, clover, cabbage, and processing tomato transitioning to organic was established in soil previously in a conventional corn/soybean/forage agronomic rotation. The experimental design was a split plot in a randomized complete block design with 4 replications. Each crop had 6 main plots and 24 subplots. Main plots were soil amendments: none, raw dairy manure, and composted dairy manure. Amendments were applied in spring at a rate equivalent to 101 kg N/ha and incorporated prior to planting. Subplots were weed control strategies: ZT, where weed seedlings were removed weekly for the whole season and no weeds were ever permitted to mature seeds in the field, and CP, where plots were kept weed free only for the first 5 weeks of crop growth. Weed management tactics included mowing and harvesting in clover, acetic acid spraying in winter wheat, and hand weeding and cultivation in cabbage and tomato. Hand weeding was carried out in all ZT plots for the entire growing season of the tomato and cabbage crops. Time to hand-weed was recorded and the labor cost of each strategy was computed. ZT weed management showed a greater decline in the field emergence of redroot pigweed (*Amaranthus retroflexus*), eastern black nightshade (*Solanum ptychanthum*), common lambsquarters (*Chenopodium album*), and common purslane (*Portulaca oleracea*) density over time compared to that of CP weed management. Weed seedbank emergence data indicated that there were fewer weed seeds in soil samples from ZT plots than from CP plots. Soil amendments did not affect the density of emerged weeds. In 2002, ZT and CP plots required 21.3 and 23 hours respectively to weed for 5 weeks. However, an additional 21.1 hours were required to weed ZT plots in tomato for the entire season. In 2003, 33% more labor was required to keep plots weed free in ZT than in CP. Labor costs ranged from an average of $192/ha for CP to $296/ha for ZT. Results from this study will support transitioning and existing organic farmers at the component, system and whole farm levels. Results also indicate that the ZT weed management strategy took longer and is more expensive to achieve compared to CP. However, in the long-term, as the weed population decreases, less time will be taken to achieve ZT; therefore the labor costs incurred will be reduced.

## CAN OVERPRODUCTION OF EPSPS ENHANCE FITNESS IN CERTAIN GLYPHOSATE-RESISTANT WEEDS?: AVENUES FOR RESEARCH.

Allison A. Snow*, Mark M. Loux, Bruce A. Ackley, David M. Mackey, Zachery T. Beres; The Ohio State University, Columbus, OH (177)

Over-production of EPSPS (5-enolpyruvoylshikimate-3-phosphate synthase, EC2.5.1.19) is known to contribute to glyphosate resistance (GR) in several weed species, with or without other mechanisms for glyphosate resistance. We hypothesize that boosting this key metabolic pathway also could enhance plant fitness in the absence of glyphosate. Recently, we found that transgenic crop-weed rice (*Oryza sativa*) hybrids with a *epsps* transgene driven by a ubiquitin promoter from maize had significantly enhanced EPSPS biosynthesis, seed germination, plant growth, and lifetime seed production, without exposure to glyphosate (Wang et al. 2013). We will review the design of this study and describe how our hypothesis will be tested further in *Conyza canadensis* and *Arabidopsis thaliana*. Some GR *Conyza* biotypes have been reported to over-produce EPSPS and others exhibit faster growth than GS (glyphosate susceptible) biotypes, but a causal link between EPSPS and improved growth rates or fitness has not been explored. We will discuss our methods for testing for 1) fitness differences between GR and GS biotypes of horseweed and other species, and 2) positive correlations between over-production of EPSPS and enhanced fitness in both *Conyza* and transgenic *Arabidopsis*. Understanding of the fitness consequences of over-producing EPSPS will be helpful for predicting the spread and persistence of GR weeds that exhibit this trait. In addition, our hypothesis may be relevant to crop breeding if over-producing EPSPS is associated with net gains in crop yields.

## IMPACT OF MANAGEMENT AND ATRAZINE USE ON LATE-SEASON WEED ESCAPES IN WISCONSIN CORN AND SOYBEAN FIELDS. Ross A. Recker*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (178)

Atrazine provides effective control of many small and large seeded broadleaf weeds, as well as some grass weed species, in numerous grass crops such as corn. In Wisconsin, the use of atrazine is prohibited in areas where atrazine total chlorinated residues were once found in concentrations greater than 3 parts per billion in drinking water wells. A pro-active survey of late-season weed escapes in corn and soybean fields was conducted throughout Wisconsin in 2012 and 2013. One objective of this survey was to compare weed community composition in different types of management, including previous atrazine use. To conduct the survey, an online questionnaire was distributed through electronic newsletters and email list-serves to Wisconsin producers in June 2012 and 2013 to generate contact and field history information as well as permission for in-field sampling locations. Fields were sampled for weed escapes in late-July through mid-September with methods similar to those described by Thomas in 1985. Weeds counted during the in-field sampling procedure were categorized as “expected escape” or “newly emerged” depending on whether they were mature weeds expected to produce seed or late-season weed seedlings. Weed count data were summarized for frequency, uniformity, density, and relative abundance. There were 343 total fields sampled. Past atrazine use categories were defined as “recent” for 160 fields where atrazine had been applied in the current or previous growing season (0-1 years), or “discontinued” for 109 fields where atrazine had not been applied for ≥10 years. Fields not defined by those categories (22% of data) were not included for the comparisons of past atrazine use. The relationship of weed presence or absence with past atrazine use was determined by chi-square analyses. From the 343 total fields sampled, 89 escaped weed species were documented. There was a significant relationship between the frequency of broadleaf weed escapes and past atrazine use (P= 0.0302), but not grass weed escapes and atrazine use (P = 0.1599). Specifically, there were less frequent broadleaf weed escapes in fields with recent atrazine use (61%) compared to fields with discontinued atrazine use (73 %) (P=0.0302). The density of broadleaf escapes, compared by a t-test, was also lower in fields with recent atrazine use (0.27 plants $m^{-2}$) compared to fields with discontinued use (0.60 plants $m^{-2}$) (P=0.0042). The weed escapes with the highest relative abundance in fields with recent atrazine use were giant foxtail, dandelion, yellow nutsedge, fall panicum, and common lambsquarters at 34.5, 30.8, 21.9, 20.9, and 20.0, respectively. In fields where atrazine use had been discontinued, common lambsquarters, dandelion, giant foxtail, velvetleaf, and large crabgrass had the highest relative abundance values for escaped weeds at 31.8, 31.8, 22.9, 17.0, and 15.7, respectively. In conclusion, in fields where atrazine has recently been used, compared to the discontinued use, weed communities have shifted towards more frequent, dense, and in some cases abundant broadleaf weed species.

## PALMER AMARANTH: A LOOMING THREAT TO SOYBEAN PRODUCTION IN THE NORTH CENTRAL REGION? Adam S. Davis*[1], Aaron G. Hager[2], Bryan G. Young[3]; [1]USDA-Agricultural Research Service, Urbana, IL, [2]University of Illinois, Urbana-Champaign, IL, [3]Southern Illinois University, Carbondale, IL (179)

Palmer amaranth is an economically important weed of soybeans in the southern U.S., but does not yet cause many problems in IL. Illinois farmers are interested in knowing whether Palmer amaranth will be a problem for them in coming years. We transplanted Palmer amaranth genotypes from around the southern U.S. at three common garden locations in southern, central and northern IL, where they competed with soybean. Our objectives were to determine if a given Palmer amaranth genotype could a) survive at a location, and b) cause soybean yield loss. All genotypes established and competed with soybeans at all IL locations in the two study years, 2010 and 2011. The damage niche of Palmer amaranth in IL does not appear to be limited by growing conditions or weed genotype, but only by seed introductions. Farmers should prioritize use of clean seed, scouting and identification of Palmer amaranth, and early eradication if a patch shows up in one of their fields.

SOMETHING WICKED THIS WAY COMES: NEW REPORTS AND HERBICIDE RESISTANCE PROFILES OF INVASIVE PALMER AMARANTH POPULATIONS IN ILLINOIS. Chance W. Riggins*, Aaron G. Hager, Patrick Tranel; University of Illinois, Urbana-Champaign, IL (180)

Over the last few years, new populations of Palmer amaranth were identified in several Illinois counties north from where it was previously known to occur. The density of most populations is relatively low, and often these plants occur only in small patches. However, these occurrences suggest that Palmer amaranth is expanding its range northwards into a region where farmers are already struggling to cope with other weedy amaranth species, most notably waterhemp. Successful weed management depends on accurate species identification, which is often difficult for members of the genus *Amaranthus*. Moreover, species verification can be further compounded by that fact that some amaranth species are known to form natural hybrids. The potential for hybridization raises additional concerns that herbicide resistances, which have evolved with remarkable efficiency in *Amaranthus*, may be transferred among species via interspecific gene flow. With these considerations in mind, we initiated a service at the beginning of the 2013 growing season to accept samples of suspect Palmer amaranth plants for species identity testing using molecular-based techniques. All plant samples were acquired by solicitation with an accompanying questionnaire asking for general site characteristics regarding field use and history, observed density and distribution of Palmer amaranth, and whether other amaranth species occurred in the same vicinity. DNA was extracted from tissue samples and analyzed using species-specific molecular markers. In addition, DNA-based assays for resistance to ALS-inhibitors (Trp574Leu mutation) and glyphosate (EPSPS amplification) were conducted on confirmed Palmer samples to gain a preliminary assessment of whether resistance was present in these populations. Fifty-seven plants from 23 locations in 19 counties in Illinois were tested. All but three submissions were confirmed to be Palmer amaranth, and the former range of Palmer amaranth was expanded to include 10 new counties in central and northern Illinois. Results also revealed that resistance to glyphosate and ALS inhibitors is present in several of these Palmer amaranth populations.

SURVEY OF GIANT RAGWEED DISTRIBUTION AND SPREAD IN THE NORTH CENTRAL REGION. Emilie E. Regnier*[1], Christopher Holloman[1], Steven K. Harrison[1], Mark M. Loux[1], Ramarao Venkatesh[1], Robert A. Ford[1], Robin Taylor[2], Florian Diekmann[1]; [1]The Ohio State University, Columbus, OH, [2]Texas A&M University, Temple, TX (181)

Giant ragweed is one of a relatively few native plant species that is a major weed of grain crops in North America. We conducted a web-based survey of Certified Crop Advisors in the Corn Belt to determine the distribution of giant ragweed and gain insights into possible factors associated with its spread. The survey asked participants to provide their perceptions and county-level estimates of giant ragweed related to its first occurrence as a problematic weed in crop fields, the proportion of crop acres infested, and habitats where found. Based on the survey responses, giant ragweed appeared in crop fields earlier in the east-central Corn Belt and later in the surrounding areas, and in most counties appeared in corn crops first, especially in the east-central region. Nearly all respondents indicated that giant ragweed was already present in non-crop habitats before appearing in crop fields. The reported time lag between its appearance in non-crop areas and crop fields was shorter in the east-central area than in the more outlying areas. The most frequent non-crop area in which giant ragweed was reported to appear first was fencerows, particularly in the east- and north-central areas of the Corn Belt. In the more outward areas, a greater variety of environments were reported, including roadsides, ditch banks, and riverbanks. Giant ragweed was listed as the most difficult weed to manage in counties located in Indiana, Wisconsin, Minnesota, Iowa and Nebraska. Most of these counties were located near the upper Mississippi River where Wisconsin, Minnesota, Iowa, and Illinois meet. Counties reporting giant ragweed present in 60% or more of crop fields were located in this same region but also southward along the Mississippi to Tennessee, west of the Mississippi along the Iowa-Missouri border and into eastern Nebraska, and also along the Missouri River in Missouri. East of the Mississippi, counties with giant ragweed present in 60% or more of crop acres were located in northwest Illinois, most of Indiana, and west-central Ohio. Based on these results we hypothesize that giant ragweed has spread outward in the Corn Belt from the east-central region, and is currently spreading into crop fields especially toward the north and west. We hypothesize that it spreads initially through a variety of non-crop edge habitats, then becomes established in fencerows, and then in crop fields.

EFFICACY OF WEED MANAGEMENT SYSTEMS IN MGI SOYBEANS. Bryan G. Young*[1], Lawrence E. Steckel[2], Scott E. Cully[3], James C. Holloway[4]; [1]Southern Illinois University, Carbondale, IL, [2]University of Tennessee, Jackson, TN, [3]Syngenta, Marion, IL, [4]Syngenta, Jackson, TN (182)

Weed management in soybean has progressively become more challenging as a direct result of weeds adapting to the glyphosate-resistant soybean production system and the excessive reliance on glyphosate. Recent commercial efforts to introduce alternate herbicide chemistry such as the PPO-inhibiting herbicides for waterhemp control have provided only temporary improvements as waterhemp with multiple resistance to glyphosate and PPO-inhibiting herbicides applied postemergence has escalated in recent years in response. A new herbicide-tolerance soybean trait is under development that confers resistance to three herbicide active ingredients: Mesotrione, Glufosinate, and Isoxaflutole (MGI). This trait has been introduced to soybean cultivars which also have resistance to glyphosate which allows for the use of several herbicide mode of action groups to be used in MGI soybeans for improved management of problematic and glyphosate-resistant weed species. Field experiments were conducted at several universities in 2012 and 2013 to evaluate the soybean response and weed control from herbicide programs enabled by the MGI system compared with commercial standard programs. Soybean injury from preemergence treatments that included various combinations of mesotrione, *s*-metolachlor, fomesafen, and metribuzin was 5% or less in 14 of the 16 site-years. Several preemergence herbicide treatments resulted in greater than 5% injury in 2013 in TN and MS with the most extensive injury associated with metribuzin and the standard comparison flumioxazin. Soybean injury following the postemergence applications were variable by site-year with treatments containing the premix of mesotrione, *s*-metolachlor, and glyphosate or fomesafen resulting in the greatest injury (up to 34%) by 11 to 16 DAT with the average soybean injury across sites being less than 10% for treatments without fomesafen. Control of both grass and broadleaf weed species was variable by site-year and weed species. However, control of *Amaranthus* spp. (AMATA, AMAPA, AMASS, AMARE), *Ipomoea* spp. (IPOSS, IPOHE), common lambsquarters, and velvetleaf by 21 to 40 days after the POST application was generally over 90% for all herbicide treatments. In most instances, the control of weed species was similar or greater than the commercial standard comparison treatments. Thus, the MGI soybean trait has the potential to improve weed management in soybean and lead toward greater herbicide mode of action diversity.

GLYPHOSATE WEEDS IN ONTARIO. Peter H. Sikkema*[1], Darren Robinson[1], Francois Tardif[2], Mark B. Lawton[3], Nader Soltani[1]; [1]University of Guelph-Ridgetown, Ridgetown, ON, [2]University of Guelph, Guelph, ON, [3]Monsanto, Guelph, ON (183)

There are three weed species with confirmed resistance to glyphosate in Ontario, Canada among the 24 globally known glyphosate-resistant weeds. Giant ragweed (seed collected in 2008), horseweed (seed collected in 2010), and common ragweed (seed collected in 2011) are the three species confirmed to be glyphosate-resistant (GR) in Ontario. Surveys show that over time the number of locations is increasing and GR weeds are found over a wider geographical area. Field trials were established at various sites with GR giant ragweed and horseweed in 2010-2012 to evaluate control options in soybean. GR giant ragweed survived glyphosate applied at 10,800 g ae/ha (86% control). Among enhanced burndown herbicides evaluated, 2,4-D (97%) or amitrol (94%) provided the best control. Among burndown + residual herbicides evaluated, linuron (83%) or cloransulam-methyl (82%) provided the best control. Among postemergence tankmixes evaluated, cloransulam-methyl (74%) was the best control option but was extremely variable (40-99%). In dicamba-tolerant soybean, dicamba provided good to excellent control. Glyphosate resistant horseweed survived glyphosate applied at 10,800 g ae/ha (84% control). Among enhanced burndown herbicides evaluated, saflufenacil (97%) and saflufenacil/dimethenamid-p (96%) provided the best control. Among burndown + residual herbicides evaluated, metribuzin (99%), flumetsulam (94%), and cloransulam-methyl (89%) provided the best control. Among postemergence tankmixes evaluated, cloransulam-methyl (51%) and chlorimuron (45%) provided marginal control. In dicamba tolerant soybean, dicamba provided good to excellent control of GR horseweed depending on rate. It is important to implement weed management practices that limit the selection of additional glyphosate-resistant weeds. This will ensure the usefulness of glyphosate and glyphosate-tolerant crops for many years in the future.

## A WEED SCIENTISTS PERSPECTIVE ON COVER CROPS IN MISSOURI. Kevin W. Bradley*, John Schultz, Eric B. Riley, Jimmy D. Wait; University of Missouri, Columbia, MO (184)

In recent years, cover crops have become a more popular component of corn and soybean production systems in the Midwest. Multiple field experiments were conducted in 2012 and 2013 to determine: 1) the effects of various cover crop species on subsequent winter and summer annual weed emergence, 2) which corn or soybean herbicide programs are most likely to carryover and cause injury to a variety of cover crop species planted in the fall, and 3) which herbicide programs provide effective kill of cover crop species prior to corn or soybean planting in the spring. The initial results from these experiments indicate that several cover crop species provided reductions in winter annual weed emergence, but only cereal rye (*Secale cereale* L.) and wheat (*Triticum aestivum* L.) provided substantial reductions in the emergence of summer annual weeds like waterhemp (*Amaranthus rudis* Sauer) through the spring and summer. Several herbicides applied to corn or soybean during the 2013 growing season resulted in carryover injury to fall-planted cover crop species. By 28 days after emergence (DAE), herbicide treatments that contained the active ingredients atrazine, clopyralid, flumetsulam, fomesafen, imazethapyr, isoxaflutole, mesotrione, and sulfentrazone resulted in substantial carryover injury to tillage radish. Crimson clover (*Trifolium incarnatum* L.) stands were reduced by clopyralid and fomesafen, while Austrian winter pea [*Pisum sativum* L. *ssp. arvense* (L.)Poir.] and hairy vetch (*Vicia villosa* Roth) stands were reduced by clopyralid and flumetsulam. Wild oat (*Avena fatua* L.) and Italian ryegrass [*Lolium perenne* L. *ssp. multiflorum* (Lam.) Husnot] stands were reduced by imazethapyr and pyroxasulfone, while wheat and cereal rye stands were not reduced by any of the herbicide treatments evaluated. Results from spring burndown experiments indicate that early and timely applications of herbicides are required in order to achieve acceptable kill of certain cover crop species, especially wheat, Italian ryegrass, and crimson clover. For example, glyphosate burndown combinations provided from 87 to 93% Italian ryegrass control when applied on April 2 to 15-cm plants, from 65 to 81% control when applied on April 22 to 36-cm plants, and from 47 to 65% control when applied on May 16 to 90-cm plants.

## ITALIAN RYEGRASS (*LOLIUM MULTIFLORUM*) - FRIEND OR FOE? James R. Martin*; University of Kentucky, Princeton, KY (185)

Italian ryegrass grows as a cool-season annual grass in Kentucky where it is embraced by some growers as a beneficial plant while others consider it a problem weed. Italian ryegrass is a native of southern Europe and was introduced as a forage grass during the Colonial days into the United States. Until recently, Italian ryegrass was grown mostly in the South and was not well adapted for Kentucky due to poor winter-hardiness. Interest in Italian ryegrass in the late 1990’s prompted University of Kentucky to begin a ryegrass variety testing program. Results of these trials showed that breeders had developed a number of Italian ryegrass varieties that had sufficient winter hardiness to survive in Kentucky’s climate. Italian ryegrass tends to have good seedling vigor and plants emerge faster compared with most other grasses grown in Kentucky. These characteristics make Italian ryegrass a good companion crop to mix with other grasses to achieve quick cover to protect against soil erosion in waterways, steep slopes, or similar areas prone to erosion. While Italian ryegrass is not a high quality turfgrass, it is sometimes used in overseeding dormant warm-season lawns in the fall. The fact Italian ryegrass seed is relatively inexpensive compared to other grass seed is another benefit of this species. Italian ryegrass has greater overall productivity than most other cool-season forage grasses that have a similar growing period. Forage specialists report yields ranging from 2.5 to 6 tons per acre. Italian ryegrass is considered one of the greatest quality forage grasses that have high protein, digestibility, and numerous vitamins and minerals. Its high quality makes Italian ryegrass a good source of feed required for dairy cows. There is increasing interest among some Kentucky growers to use Italian ryegrass as a cover crop. The leafy growth of Italian ryegrass provides a good cover that can suppress weeds and limit soil erosion. University of Kentucky soil scientists are currently investigating the impact of Italian ryegrass as a cover crop on remediation of fragipans in poorly drained soils. The weedy characteristics of Italian ryegrass are a major concern of weed scientists. Its ability to grow rapidly soon after emergence gives it a competitive advantage over other plants, including grain crops as well as turf and companion forage crops. Research in Arkansas shows Italian ryegrass is capable of producing as many as 45,000 seeds per plant. While Italian ryegrass seeds do not persist for a long time in soil, there is a small percentage that may survive for more than a single season. Italian ryegrass is the most competitive weed in wheat in Kentucky. One plant per square foot can limit wheat yield by nearly 4%. Since it matures about the same time as wheat, the seeds of Italian ryegrass are often spread with combines during the harvesting process. Ryegrass infestations often begin in wheat along field borders and especially waterways where it is sown to protect against soil erosion. If these areas are not clipped before wheat harvest, combines can spread ryegrass seed from these areas into the fields. Once Italian ryegrass is present in wheat, it often evolves as a problem in subsequent rotational crops, especially corn. Well established ryegrass plants that overwinter are difficult to control in corn, particularly where no-tillage practices are utilized. Sequential applications of burndown treatments are often needed to achieve the desired level of control of Italian ryegrass in corn. A three-year study at the University of Kentucky indicated a single application of paraquat provided only 35% ryegrass control and resulted in a corn yield of 89 bu/A. This compares to sequential applications of the tank mixture of paraquat plus atrazine which provided 94% ryegrass control and had a corn yield of 149 bu/A. Ryegrass can harbor various pests including the prairie vole (*Microtus ochrogaster*) that impact grain crops. A heavy ryegrass cover provides an excellent habitat for prairie voles that feed on seeds, shoots and roots of plants including wheat, corn, and soybeans. A major concern with using Italian ryegrass in Kentucky is that it is prone to developing herbicide resistance. The International Survey on Herbicide Resistant Weeds reports four biotypes of Italian ryegrass with single site of action resistance and six biotypes with multiple sites of action. At the present time, Kentucky has documented a few isolated cases of ACCase-resistant Italian ryegrass and ALS-resistant Italian ryegrass in wheat. It is interesting to note that most of Italian ryegrass seed sold in Kentucky was produced in Oregon. The first ACCase-resistant ryegrass to be documented in the United States was in 1987, in wheat, in Oregon. Glyphosate-resistant Italian ryegrass was reported in Oregon in 2004 in orchards. Growers who plan on growing Italian ryegrass in Kentucky are encouraged to purchase their seed from reputable sources. The certification process for marketing Italian ryegrass seed does not address the presence of herbicide resistance; therefore, there is no assurance the seed is free of herbicide resistance. Growers are advised to use cultural and chemical control strategies that are effective in managing Italian ryegrass and observe for escapes.

ENLIST AHEAD: NOVEL MANAGEMENT AND STEWARDSHIP RESOURCES FOR THE ENLIST WEED CONTROL SYSTEM. David E. Hillger*[1], Jonathan Siebert[2], Ralph Lassiter[3], Byron Hendrix[4], John Laffey[5], Gary A. Finn[1], Bruce E. Maddy[6], Eric Thorson[1], Damon Palmer[1]; [1]Dow AgroSciences, Indianapolis, IN, [2]Dow AgroSciences, Leland, MS, [3]Dow AgroSciences, Cary, NC, [4]Dow AgroSciences, Lakeville, MN, [5]Dow AgroSciences, Maryville, MO, [6]Dow AgroSciences, Noblesville, IN (186)

Dow AgroSciences is developing the Enlist™ Weed Control System, a novel weed control technology to combat herbicide-resistant and hard-to-control weed populations that will improve upon the proven benefits of the glyphosate-tolerant cropping system. The Enlist Weed Control System will be enabled through the cultivation of Enlist crops which contain multiple herbicide tolerance traits that will allow for the post emergence application of Enlist Duo™ herbicide, a proprietary blend of glyphosate and 2,4-D choline. Just as important as the trait and herbicide solution, Enlist™ Ahead is a management resource designed to help growers succeed while promoting responsible use of the system. Built on a three-pillar foundation, Enlist Ahead will offer farmers, applicators and retailers technology advancements, management recommendations and resources, and education and training. A series of training activities, offered through a variety of delivery methods, was initiated in 2013 to educate growers and applicators on the responsible use of the Enlist™ system. Participants learned how to minimize the potential for off-target movement, principles to promote weed resistance management practices, and biotechnology trait stewardship practices. Dow AgroSciences has a commitment to responsibly commercializing the Enlist Weed Control System to sustain its longevity.

ROUNDUP READY LEARNING XPERIENCE - A NEW TRAINING TOOL. Sara M. Allen*[1], Michelle M. Vigna[2], Simone Seifert-Higgins[2], Joseph J. Sandbrink[2], Adam M. Marschel[2], Barry L. Rogers[2], Matthew J. Helms[2], Tony D. White[2]; [1]Monsanto, Bonnie, IL, [2]Monsanto Company, St. Louis, MO (187)

Many growers are currently seeking new ways to effectively control weeds in soybean and cotton. The Roundup Ready® Xtend Crop System, which is pending regulatory approval, is designed to give farmers another tool to manage glyphosate-resistant weeds and improve their crop yield. Once commercially available, this will be the first time trait and chemistry products will be launched simultaneously as part of the same weed management system. Therefore, proper education and training around effective system use is important. In the summer of 2013, Monsanto successfully held Roundup Ready®

Learning Xperience events in major soybean and cotton production areas.  These events aimed at educating seed dealers, retailers, and other key stakeholders about the Roundup Ready Xtend Crop System.  Sites included various trial types to allow participants to see the performance of the system, including trait, herbicide, and application technology components.  In addition, training on the value of basic weed science principles, such as using multiple herbicide modes of action for weed control and how to maximize on-target applications, was integrated into the events.  In the future, the Learning Xperience will be expanded to include a broader group of participants.

STEWARDSHIP FOR BASF HERBICIDES. Luke L. Bozeman*[1], Sandra Wilson[1], Robert E. Wolf[2], Daniel Pepitone[1]; [1]BASF Corporation, Research Triangle Park, NC, [2]Wolf Consulting & Research LLC, Mahomet, IL (188)

A diverse approach to herbicide use, along with targeted spray application, are key stewardship components of an effective weed management program.  The goal of herbicide application is to remove weeds that may compete with the crop and reduce crop yield.  Ineffective weed control may result from applications that do not use a diverse approach to herbicide selection.  A new tool currently in development is Engenia™ herbicide, an advanced formulation of dicamba for dicamba-tolerant soybeans and cotton. The formulation further improves on-target application through reduced secondary loss potential.  A herbicide application that moves off target may cause unintended effects on non-target plant species that are contacted.  It is important that applicator training programs be made available to provide guidance on herbicide systems and proper application to mitigate off-target damage to sensitive plants and maximize product performance.  Training efforts underway and in development will be discussed.

FACTORS ASSOCIATED WITH INVASIVE PLANT DISTRIBUTION ALONG WISCONSIN ROADSIDES. Mark J. Renz*[1], Joslyn Mink[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin, Madison, Madison, WI (189)

Road construction causes large-scale disturbances necessitating revegetation. In Wisconsin, seed mixtures of Eurasian turfgrasses with and without native species are being planted to prevent establishment and spread of invasive plants. Our research assessed vegetative cover along three distinct zones across 35 roadsides in Wisconsin. Our objective was to identify factors associated with invasive plant abundance and if the addition of native plants to the seed mix reduced invasive plant cover. Roadside vegetation was dominated by planted grasses with Eurasian planted grass cover the most abundant (68-79 %). Native grass cover contributed little to planted species cover (<10%) when included in the mix, but resulted in 19-33 % more non-native grass cover, depending on the zone ($P \leq 0.05$). Invasive grass cover was between 28-33% the year after revegetation depending on the zone, but was not affected by seed mixture composition or time after revegetation. Non-planted, non-invasive or invasive forb cover ranged between 15-22 and 9-15 %, respectively, but did not differ between seed mixture composition and time after revegetation. Regression tree analysis found invasive grass cover was 25% greater along roads where over 6,850 vehicles travel daily. In contrast, no factors analyzed were associated with areas with higher invasive forb cover. Results suggest that revegetation methods used on Wisconsin roadsides that include native species in the seed mixture do not improve resistance to invasive plant invasion.  Invasive grass invasions appear closely linked to vehicular traffic, and this could be utilized to prioritize monitoring and management activities for these species.

EFFECTS OF THREE COMMON BUCKTHORN REMOVAL TECHNIQUES ON THE REGENERATION OF UNDERSTORY VEGETATION. Alexander M. Roth*, Alexandra G. Lodge, Lee E. Frelich, Peter B. Reich; University of Minnesota, St. Paul, MN (190)

Invasive plant species such as common buckthorn (*Rhamnus cathartica*) are some of the most widespread and ecologically harmful non-native species in forests of the Midwest United States. Buckthorn invasion has been shown to cause changes in nutrient cycling and can negatively affect herbaceous and woody plant species abundance and richness, making buckthorn a species of concern for land managers. However, removal of buckthorn is costly and ineffective, and the restoration process is often plagued by re-invasion. In order to improve restoration success, invasive species managers must not only consider a method's capacity to remove buckthorn, but also how the method affects the conditions that control the germination and subsequent regeneration of both native and invasive plants. This study examined the effects of three buckthorn removal methods on the regeneration of understory vegetation. We established four removal sites with 12 plots each in upland, mesic oak forests in central Minnesota, USA. Vegetation and environmental plot characteristics were surveyed prior to buckthorn removal in fall 2011. These same characteristics were re-surveyed twice during the growing season in both 2012 and 2013 to document re-vegetation and community succession. Compared to control plots and to pre-removal levels, all removal methods significantly increased available light at the forest floor, providing a potentially important resource for species regeneration. ANOVA analysis showed that plots where weed wrenching was used attained higher herbaceous percent cover and species richness than any other treatment, suggesting that disturbing the soil and exposing the seedbank could be important for native species regeneration. Furthermore, plots where herbicide was used (cut and paint and basal bark application) saw temporary declines in both cover and richness of herbaceous and woody species, which recovered to surpass control plot levels by 2013. The results of this study have implications for managing invaded forests and suggest that removal methods have differing effects on subsequent community regeneration. Future studies should track long-term community succession and investigate the ability of post-removal techniques to increase diversity and resist buckthorn re-invasion.

FOLIAR-APPLIED HERBICIDES FOR SALTCEDAR CONTROL. Walter H. Fick*; Kansas State University, Manhattan, KS (191)

Saltcedar (*Tamarix ramosissima*) is a woody invasive species found on lowland sites near rivers and streams from North Dakota to Texas. In Kansas, saltcedar is found primarily along the Cimarron and Arkansas rivers. The objective of this study was to determine the impact of application date on the efficacy of nine herbicides applied for saltcedar control. The study site was located on the Cimarron National Grasslands near Elkhart, KS. The herbicides were applied with a backpack sprayer in 467 L $ha^{-1}$ total spray solutions with the addition of a 0.5% non-ionic surfactant. Treatments were applied in late July to early August or in early to mid-October each year from 2009 to 2012. Herbicides were applied as individual plant treatments with 8-23 trees per treatment. Saltcedar mortality was determined the growing season after application. Chi square analysis was used to determine differences among treatments at the 0.05 level of probability. In 2009, foliar applications of imazapyr at 1.2 and 2.4 g $L^{-1}$, and imazapyr + glyphosate at 1.2 + 5.5 g $L^{-1}$, provided 75-100% control of saltcedar with no differences between dates of application. Similar results occurred in 2010 with imazapic at 2.4 g $L^{-1}$ also providing 100% control. Additional herbicides were evaluated in 2011 and 2012 including triclopyr at 4.8 g $L^{-1}$, aminopyralid + triclopyr amine at 0.3 +3.6 g $L^{-1}$, aminopyralid + metsulfuron at 0.26 + 0.05 g $L^{-1}$, aminocyclopyrachlor + methsulfuron at 0.44 + 0.14 g $L^{-1}$, and aminopyralid + metsulfuron + triclopyr at 0.26 + 0.05 + 1.2 g $L^{-1}$. All of these treatments provided $\leq$ 50% control on any date of application in 2011 or 2012. The imazapyr and imazapyr + glyphosate treatments provided 54-100% control in 2011 and 2012. Late summer precipitation, although below normal, may have contributed to increased mortality following the October 2011 treatments of triclopyr, aminopyralid + metsulfuron, and aminocyclopyrachlor + metsulfuron. In 2012 herbicide response was usually equal to or more effective when applied in late July compared to October. Over all treatment dates, the only herbicide more effective applied in October compared to late July was aminocyclopyrachlor + metsulfuron, 41 vs 4%, respectively. Imazapic provided an average of 79% control of saltcedar and appears to be an alternative to using imazapyr or imazapyr + glyphosate mixtures.

*AILANTHUS* WILT, A POTENTIAL BIOCONTROL AGENT IN OHIO FORESTS? Joanne Rebbeck*[1], Joan Jolliff[1], Donald Davis[2], Eric O'Neal[2]; [1]Northern Research Station, Delaware, OH, [2]Penn State University, University Park, PA (192)

Populations of the invasive tree, Ailanthus continue to increase within disturbed forested landscapes. Mechanical control methods are impractical since multiple cuttings are required to deplete stored root carbohydrates. Typically mechanical methods combined with an herbicide treatment can be effective. Chemical control can be costly requiring multiple applications. Given these obstacles, the use of a highly specific biological control agent could offer great promise. A wilt-causing fungus as a potential biological control agent of Ailanthus was identified by Schall and Davis after isolating *Verticillium nonalfalfae* from dead and dying Ailanthus trees within forested areas in PA. After much rigorous testing and numerous trials, this soil-borne fungus was found to be very specific and deadly to Ailanthus. Symptoms of Ailanthus infected with the fungus include wilt, premature defoliation, terminal dieback, yellow vascular discoloration, and mortality. Since 2009, the same fungus has been found at multiple forest stands in VA. In summer 2012, Ailanthus wilt was confirmed in a southern Ohio stand. In 2013, Rebbeck began testing this potential biocontrol agent. Greenhouse inoculation studies are underway to verify that additional native tree species are not susceptible to the fungus. Preliminary greenhouse results on native Ohio seed sources of ash, beech, elm, and oak (black, chestnut, northern red oak and white) seedlings are encouraging – to date no signs of wilt have been observed. These trials will continue to be monitored through 2014. Pilot field inoculation trials in Ohio are planned for May 2014. Since many forested areas within Ohio have varying densities of *Ailanthus*, developing and testing *V. nonalfalfae* as a biocontrol agent of *Ailanthus* is highly desirable. This potential biocontrol agent provides an added benefit - the fungus is native to North America so we are not introducing a new exotic organism. A further benefit is that once the fungus is introduced into a stand, it can spread from tree to tree through root grafting and naturally build up in the forest.

THE EFFECTS OF SITE FERTILITY ON BIOLOGICAL CONTROL TARGETING PURPLE LOOSESTRIFE (*LYTHRUM SALICARIA*). Stephen M. Hovick*[1], Chris J. Peterson[2], Walter P. Carson[3]; [1]The Ohio State University, Columbus, OH, [2]University of Georgia, Athens, GA, [3]University of Pittsburgh, Pittsburgh, PA (193)

Biocontrol success varies widely across landscapes, often for unknown reasons. Understanding this variability can help optimize invasive species management while also informing our understanding of trophic linkages. To address these issues, we tested three hypotheses with contrasting predictions regarding the likelihood of biocontrol success. 1) The *Biocontrol Effort* hypothesis: invasive populations are regulated primarily by top-down effects, predicting increased biocontrol efforts alone (e.g., more biocontrol agents or more time since agent release) will enhance biocontrol success. 2) The *Relative Fertility* hypothesis: invasive populations are regulated primarily by bottom-up effects, predicting nutrient enrichment will increase dominance by invasives and thus reduce biocontrol success, regardless of biocontrol efforts. 3) The *Fertility-Dependent Biocontrol Effort* hypothesis, which accounts for both mechanisms: top-down effects will only regulate invasive populations if bottom-up effects are weak. It predicts that greater biocontrol efforts will increase biocontrol success, but only in low-nutrient sites. To test these hypotheses we surveyed 46 sites across three states with prior releases of *Galerucella* beetles, the most common biocontrol agents used against invasive purple loosestrife (*Lythrum salicaria*). We found strong support for the Fertility-Dependent Biocontrol Effort hypothesis, as biocontrol success occurred most often with greater biocontrol efforts, but only in low-fertility sites. This result held for early-stage metrics of biocontrol success (higher *Galerucella* abundance) and ultimate biocontrol outcomes (decreased loosestrife plant size and abundance). Presence of the invasive grass *Phalaris arundinacea* was also inversely related to loosestrife abundance, suggesting that biocontrol-based reductions in loosestrife made secondary invasion by *P. arundinacea* more likely. Our data suggest that low-nutrient sites be prioritized for loosestrife biocontrol and that future monitoring account for variation in site fertility or work to mitigate it. We introduce a new framework that integrates our findings with conflicting patterns previously reported from other biocontrol systems, proposing a unimodal relationship whereby nutrient availability enhances biocontrol success in low-nutrient sites but hampers it in high-nutrient sites. Our results represent one of the first examples of biocontrol success depending on site fertility, which has the potential to inform biocontrol-based management decisions across entire regions and among contrasting systems.

VEGETATIVE DISPERSAL OF AN INVASIVE BIOENERGY CROP: SHOULD WE BE WORRIED? Natalie M. West*[1], David P. Matlaga[2], Adam S. Davis[1]; [1]USDA-Agricultural Research Service, Urbana, IL, [2]Susquehanna University, Selinsgrove, PA (194)

*Miscanthus* x *giganteus*, a widely planted biofeedstock, has been largely ignored in discussions of potentially invasive biofuel crops. As a seed infertile species, it lacks an obvious mechanism of long distance dispersal, a key contributor to invasion rate, and has thus been considered a low escape risk. However, cultivation shelters plants from demographic stochasticity and increases propagule pressure, potentially reducing limitations that prevent low risk species from taking advantage of rare dispersal events. Risk assessments of this species assumes proper management through time as well as the infrequency of events, such as scouring and flooding, that would facilitate escape of vegetative rhizome fragments. Combining data from small scale rhizome fragmentation and movement experiments and estimates from the literature, we parameterized an individual based model to examine the rate of *M.* x *giganteus* spread given two dispersal scenarios. We further evaluated the sensitivity of our estimates in response to different buffer widths and monitoring intensities, two key strategies advised for containing biofuel crops. We found that estimates of the clonal expansion rate alone were sufficient to allow the crop to outgrow setbacks of 3 m or less within 11 to 15 years with low monitoring intensities. Further, models that included the possibility of rhizome dispersal from fields and scouring at field edges support the possibility of long distance dispersal and establishment if management intensities are too low. Our study highlights the importance of considering minimum enforced management guidelines to maintain the ecological integrity of the agricultural landscape.

THE EFFECT OF EMERALD ASH BORER-CAUSED CANOPY GAPS ON UNDERSTORY INVASIVE SHRUBS AND FOREST REGENERATION. Brian M. Hoven*[1], David Gorchov[1], Kathleen Knight[2]; [1]Miami University, Oxford, OH, [2]USDA Forest Service, Delaware, OH (195)

Widespread defoliation and gap formation by invasive insect herbivores can lead to extensive changes to forest structure and canopy composition. Emerald ash borer (EAB), *Agrilus planipennis,* is an invasive forest pest of particular concern to deciduous forests of eastern North America. Mature ash, *Fraxinus* spp*.,* will succumb to larval feeding in 1-4 years, resulting in forest canopy gaps which could greatly benefit invasive plant species due to dramatic increases in light. Additionally, tree sapling and seedling responses within EAB-generated canopy gaps have major implications for long-term forest composition. To investigate the response of understory woody plant communities to EAB-induced ash mortality, we tagged and measured shrubs, tree seedlings, and saplings in plots established for long-term EAB monitoring by the United States Forest Service (USFS). Metrics of interest include recruitment, growth, cover, and fecundity of native and invasive shrubs, with a special focus on the invasive Amur honeysuckle, *Lonicera maackii*, as well as recruitment and growth of tree seedlings and saplings. Measurements were made in 2012 and 2013, with plans to remeasure in 2014, at 24 sites located throughout western and central Ohio. White-tailed deer density is expected to be an important covariate, and will be estimated by fecal pellet counts. All data collected is pooled with data previously and currently collected by the USFS concerning canopy tree growth, assessment of live ash health and dead ash break-up, canopy openness, as well as Forest Inventory and Analysis cover data. Preliminary results indicate overall ash decline to be most advanced near initial infestation (Northwest Ohio), yet is quickly advancing throughout western and central portions of the state. A trend between greater ash basal area, lower ash quality, and greater canopy openness has been observed. Invasive species including: *L. maackii*, *L. morrowii*, *Ligustrum* sp., *Berberis thunbergii*, *Euonymus alatus*, *Rosa multiflora*, *Elaeagnus umbellata*, *Pyrus* sp., *Rhamnus frangula*, and *R. cathartica* were all identified in at least one site. Fruit set of *L. maackii* was better predicted by shrub basal area than height or canopy openness. These data will be analyzed by path analysis, and incorporated into forest vegetation software (FVS) to extrapolate current phenomenon and make long-term forest composition predictions that can assist in guiding resource management with regards to emerald ash borer.

AMINOPYRALID RESEARCH SUMMARY FOR AQUATIC LABELING. Vanelle F. Peterson[1], John Jachetta[2], Patrick L. Havens[2], Louise A. Brinkworth[2], William Kline[3], William T. Haller[4], John Troth[2], Ernest S. Flynn*[5]; [1]Dow AgroSciences LLC, Mulino, OR, [2]Dow AgroSciences LLC, Indianapolis, IN, [3]Private Researcher, Ballground, GA, [4]University of Georgia, Gainesville, FL, [5]Dow AgroSciences, Ankeny, IA (196)

Aminopyralid is a member of the pyridinecarboxylic acid family of herbicides and controls noxious and invasive broadleaf weeds in rangeland, permanent grass pastures, Conservation Reserve Program (CRP) acres, non-cropland areas including industrial sites, rights-of-way (such as roadsides, electric utility and communication transmission lines, pipelines, and railroads), non-irrigation ditch banks, natural areas (such as wildlife management areas, wildlife openings, wildlife habitats, recreation areas, campgrounds, trailheads and trails), and grazed areas in and around these sites. It is currently registered in products either alone (Milestone®) or with other active ingredients such as metsulfuron, clopyralid, triclopyr, or 2,4-D (for example, Opensight®, Sendero®, Capstone®, or ForeFront® HL, respectively). The current labels state, "*It is permissible to treat non-irrigation ditch banks, seasonally dry wetlands (such as flood plains, deltas, marshes, swamps, or bogs) and transitional areas between upland and lowland sites. Milestone can be used to the water's edge. Do not apply directly to water and take precautions to minimize spray drift onto water.*" The labels also state, "*Do not contaminate water intended for irrigation or domestic purposes. Do not treat inside banks or bottoms of irrigation ditches, either dry or containing water, or other channels that carry water that may be used for irrigation or domestic purposes.*" Aminopyralid degradation rate in water in sunlight (photolytic half-life of 0.6 days) is similar to triclopyr, an active ingredient registered for aquatic uses (half-life of 0.5 days). Therefore, to expand the utility of aminopyralid containing products, research was conducted in 2010 to gather data for a submission to support the addition of aquatic uses to aminopyralid product labels. Research studies in ponds and in moving water generated residue data in order to establish tolerances for fish, shellfish and crustaceans and define the dissipation kinetics in water and sediment over time. Pond studies were conducted in Texas and Indiana and moving water studies in Oregon and Florida. Data were used in submissions to support aquatic uses for Milestone, GrazonNext® HL, ForeFront HL, Capstone, and PasturAll® HL. Following approval labels are expected to have no restrictions on recreational or livestock use of water after applications but use will not be permitted on the inside banks of irrigation ditches. Use precautions and restrictions on use of water treated with Milestone for irrigation will likely be included on the new label.  Registration is anticipated for the use season in 2014.

®™Trademark of The Dow Chemical Company (“Dow”) or an affiliated company of Dow

## FUNCTIONAL TRAIT DIFFERENCES BETWEEN NATIVE AND INVASIVE PLANTS IN DECIDUOUS FORESTS OF THE UPPER MIDWEST.

Alexandra G. Lodge*[1], Alexander M. Roth[1], Timothy Whitfeld[2], Peter B. Reich[1]; [1]University of Minnesota, St. Paul, MN, [2]Brown University, Providence, RI (197)

There is no consensus in the literature as to which plant traits allow a species to become invasive in a new range – results vary across systems and species. There are two overarching theories of how invasive plants establish in new areas. The first is the “try harder” approach, where an exotic species will have an extreme value of one or more functional traits that allows it to persist better than the native species. Alternatively, under the “join the locals” approach, exotic species possess traits within the range of those in the resident community, allowing them to establish amongst similar species. We first investigated whether the native and exotic species found in the temperate oak-dominated upland forests of Minnesota differed in their average trait values. We examined eight traits: plant height, leaf nitrogen and carbon content, specific leaf area, seed mass, mycorrhizal type, growth form, and wood density (for woody species). Next, we examined whether the multidimensional functional trait space occupied by these exotic species differed from or overlapped with the total trait space occupied by all native species surveyed. Finally, in order to examine how exotic species fit into actual established plant communities, we compared trait space occupied by natives and exotics at more than fifty individual forest sites in Minnesota.  Exotic species had greater mean leaf nitrogen levels than native species. Additionally, among woody plants, exotic species were significantly shorter than native plants. The functional trait space occupied by all observed exotic species overlapped almost completely with that of all observed native species, suggesting that invasive plants in this system have similar trait values to native species and are “joining the locals” when they invade. In our comparisons of the trait space of specific communities we found mixed results, although at the majority of sites invasives occupied trait spaces similar to those of resident species.  These results may give insights into making predictions as to which new exotic species are likely to become invasive in this system. We suggest that newly introduced species that are more similar to resident species may be more likely to successfully establish and become invasive.

## EFFECTS OF THE INVASIVE SHRUB *LONICERA MAACKII* AND A GENERALIST HERBIVORE, WHITE-TAILED DEER, ON FOREST FLOOR PLANT COMMUNITY COMPOSITION.

Jessica R. Peebles-Spencer*, David Gorchov; Miami University, Oxford, OH (198)

Once an invasive species is introduced to an area, it can become disruptive and detrimental to biological communities.  One such invasive plant species is Amur honeysuckle (*Lonicera maackii* (Rupr.) Herder), a shrub with an extended leaf phenology, high freeze tolerance, and high shade tolerance.  After *L. maackii* invades, it negatively affects both tree and herb species. White-tailed deer (*Odocoileus virginianus*), overly abundant generalist herbivores, are also a factor in driving change in forest composition.  In order to assess the combined effect *L. maackii* and white-tailed deer on forest floor plant composition, pairs of 20m-by-20m deer exclosures and controls were established at each of five sites in the Miami University Natural Areas.  In half of each exclosure or control, *L. maackii* was removed and stumps were treated with herbicide in 2010, resulting in 20 20 x 10 m plots. We determined species identity and cover of all plants < 1 m in 18 subplots per plot using a modified Daubenmire plot method.  We sampled plots in spring and in summer in 2011, 2012 and 2013; data from 2011 are used as baseline data.  Species richness from each subplot was calculated and assessed using analysis methods for a split-plot design, and was fit using a linear mixed effects model using deer exclosure as a whole plot factor, *L. maackii* removal as the split plot factor, and site as a random factor. Deer exclosure had a somewhat significant effect on species richness ($P < 0.1$) in summer 2012; areas with deer excluded have higher species richness.   *Lonicera maackii* removal plots had higher species richness in spring 2012 and 2013 and summer 2012 (all $P < 0.05$) and somewhat higher in summer 2013 ($P < 0.1$).   There was a somewhat significant interaction between deer exclosure and *L. maackii* removal on species richness ($P < 0.1$) in spring of 2013; areas with deer excluded and *L. maackii* removed have higher species richness.   To examine patterns of community composition of the plots, we used non-metric multidimensional scaling (NMDS), a type of ordination.  Significance of treatment effects will be determined using permutational multivariate analysis of variance (PERMANOVA). This experiment is continuing to determine longer term responses of the herb layer species richness and composition to deer exclosure and *L. maackii* removal, and their interaction. Results from this study can inform management for both *L. maackii* and deer.

### THE ROLE OF WHITE-TAILED DEER IN LONG-DISTANCE DISPERSAL OF AMUR HONEYSUCKLE (*LONICERA MAACKII*). Peter W. Guiden*, David Gorchov; Miami University, Oxford, OH (199)

Long-distance dispersal is an important aspect of invasive species ecology because it results in new invasion frontiers. We investigated deer-mediated long-distance seed dispersal of Amur honeysuckle (*Lonicera maackii*). This plant is a prolific invasive shrub in the eastern and midwestern US, and is known to depress survival and reproduction of both native tree and native annual species. Seeds of *L. maackii* are known to be dispersed by birds, and also to survive digestion by white-tailed deer. Developing a comprehensive understanding of *L. maackii* seed dispersal will be instrumental in slowing the spread of this invasive plant into uninvaded or restored areas. We combined published data on gut retention time and daily movement patterns of deer to project the seed shadow of *L. maackii* endozoochory through deer. Preliminary analysis shows that most *L. maackii* seeds consumed by deer should only disperse 500m from a seed source, but rarely seeds are dispersed over longer distances. Our analysis indicates that 5.4% of seeds will be dispersed between 1 and 2km, and that 2.1% of seeds will be dispersed between 2 and 8km. These rare, long-distance dispersal events likely contribute a disproportionate amount to the spread of this invader. Differences in age and sex likely influence patterns of movement and dispersal, and may lead to different seed shadows for subsets of deer. These results provide a theoretical expectation for *L. maackii* long-distance dispersal through deer that can be compared to field evidence of dispersal. This evidence will come from *L. maackii* seedlings germinating from deer pellets collected from woodlots without *L. maackii*, in Darke County, Ohio. Each woodlot will be classified based on the distance to the closest *L. maackii* seed source, in order to test our seed shadow's projected relationship between distance from a seed source and dispersal of *L. maackii* seeds. Ultimately, this study will enhance our understanding of how *L. maackii* invades new areas, and indicate which ages and sex of deer are most responsible for long-distance seed dispersal. Additionally, the dispersal of invasive *L. maackii* seeds gives new insight into the adverse ecological effects of deer.

### THE EFFECT OF TREEFALL GAPS ON THE SPATIAL DISTRIBUTION AND DISPERSAL OF FOUR INVASIVE PLANTS IN A MATURE SECONDARY UPLAND FOREST IN MARYLAND. Angela Klinczar*[1], Charlotte Freeman[2], Nicole Angeli[3], David Gorchov[4]; [1]Miami University, Orchard Park, NY, [2]Purdue University, West Lafayette, IN, [3]Texas A&M University, College Station, TX, [4]Miami University, Oxford, OH (200)

Plant invasion is contingent on several factors; one of the most prominent being invasibility. Invasibility, the intrinsic susceptibility of an area to invasion, is typically high in disturbed areas. The objective of this study is to determine the spatial distribution of invasive plants in a mature forest, to explore the role of disturbance (specifically treefall gaps) in plant invasion, and to investigate seed dispersal patterns of invasive plants. Nine hectares of secondary upland forest, divided into 2x2 m subplots, were surveyed at the Smithsonian Environmental Research Center in Maryland, USA. This stand is part of the global network of permanent forest plots coordinated by the Center for Tropical Forest Sciences (CTFS). For each subplot, invasive plants were identified, and, for the four most abundant invaders, *Rubus phoenicolasius, Berberis thunbergii, Rosa multiflora*, and *Lonicera japonica*, numbers were counted per life history stage. The height of the canopy was assessed for each subplot, and later scored to reflect gap (< 10 m) and non-gap (> 10 m). In addition, a LiDAR (Light Detection and Ranging) layer of canopy height from 2003-2005 was obtained, and processed to have a similar 10m threshold. Gaps were classified as current (field gaps), old (LiDAR gaps), and persistent (both LiDAR and field gaps). We used zonal statistics to determine the density of the various life stages of each plant in gaps. Compared to non-gap areas, densities were higher for *R. phoenicolasius* in all gap types, prostrate *L. japonica* in current and persistent gaps, and both multi-stem *Rosa multiflora* and climbing *L. japonica* in current gaps. We also examined the influence of gap size, and found that fertile *R. phoenicolasius* is positively associated with size for both current and old gaps, as were multi-stem sterile *R. phoenicolasius* for old gaps, and climbing *L. japonica* for current gaps. For individuals of the youngest stage of *R. phoenicolasius* and *B. thunbergii*, we calculated the distance to the closest reproductive individual of the same species to generate a 'seedling shadow,' and fit dispersal density 'kernels' to these distributions. For both species, kernels using the negative exponential fit better than Gaussian kernels, but dispersal distances were much longer for *B. thunbergii*. The implications of this study are to understand the mechanisms of invasion and importance of site conditions, which should inform control and management of invasive plants.

DEVELOPING INNOVATIVE MANAGEMENT STRATEGIES FOR THE INVASIVE *PHRAGMITES AUSTRALIS*. Kurt P. Kowalski, Wesley A. Bickford*; USGS-Great Lakes Science Center, Ann Arbor, MI (201)

Current methods to control invasive *Phragmites australis* on the North American landscape (e.g., repeated herbicide, burning, flooding) are resource-intensive and often ineffective. Though management efforts can produce short-term successes, continued rigorous follow-up is required to maintain desired conditions. Innovative control methods are needed to develop more sustainable, long-term landscape-level strategies. To address this need, the USGS – Great Lakes Science Center has been working with partners from Wayne State University, SUNY – Brockport, and other agencies to explore new management tools to reduce the competitive abilities of *Phragmites*. One line of research explores the relationship between systemic microbes and *Phragmites* plants. It has been well documented that microbial associations (e.g., mutualisms) greatly influence the colonizing success and production of many plants. Thus, if the associations between invasive *Phragmites* and its microbes can be disrupted, the competitive advantage of *Phragmites* may be reduced and native plant assemblages can be maintained. Our work investigates the role of symbiosis between *Phragmites* and its endophytic fungi and explores opportunities to disrupt or enhance those symbiotic relationships. USGS also has partnered with Wayne State University to explore manipulation of intracellular interactions to block specific traits from being expressed (i.e., gene silencing), thus reducing advantages it has over native plants. Gene silencing could, for example, inhibit photosynthesis or growth rate in *Phragmites*, rendering it a much less effective competitor. This research seeks to augment current control efforts to allow managers to fight the spread of the species on multiple fronts, thereby improving the overall effectiveness of *Phragmites* management.

PLANT COMMUNITY DEVELOPMENT FOLLOWING RESTORATION TREATMENTS ON A LEGACY RECLAIMED MINE SITE. Keith E. Gilland*[1], Caleb J. Cochran[1], Julia I. Chapman[2], Jenise M. Bauman[1]; [1]Miami University, Middletown, OH, [2]University of Dayton, Dayton, OH (202)

The Federal Surface Mining Control and Reclamation Act (SMCRA) of 1977 was created out of environmental concern for landscapes that were impacted by coal mining. This act enforced the replacement of topsoil, mandated grading soils to pre-mining contour, and directed the establishment of a productive vegetation cover. This reclamation protocol achieved certain goals such as erosion control, improved water quality, and buffered the pH of the soil. However, soils were also highly compacted and comprised of weedy, non-native herbaceous plants. Vegetation surveys conducted in southern Ohio have indicated little recovery of native plant species, even decades after the original reclamation. The objective of this study was to survey plant community development 2-5 years following soil treatment methods used in tree planting projects. Treatment plots were established on a south-eastern Ohio legacy surface coal mine site that was reclaimed under SMCRA in the 1980s. Treatments were: an undisturbed control plot (C), plots mechanically cross-ripped at a 1 meter depth (R), plots plowed and disked (PD), and ripped + plowed and disked (RPD). When the vegetation species richness and diversity was compared per treatment at intervals of 1,3, and 5 years, no significant patterns emerged. Three non-native species (*Lespedeza cuneata*, *Poa pratensis*, and *Festuca arundinacea)* dominated the vegetative makeup at all three sampling dates dominated the sites (78%, 74%, and 67% or relative cover in 2008, 2010, and 2013). Although the soil surface treatments did not influence differences in herbaceous plant community composition in the short term, planted trees and other woody species may facilitate shifts in vegetation by imposing changes in light levels overtime.

BICYCLOPYRONE, A NEW HERBICIDE FOR IMPROVED WEED CONTROL IN CORN. Gordon D. Vail*[1], Scott E. Cully[2], Ryan D. Lins[3], John P. Foresman[1]; [1]Syngenta Crop Protection, Greensboro, NC, [2]Syngenta, Marion, IL, [3]Syngenta, Byron, MN (203)

Bicyclopyrone is a new selective herbicide for weed control in field corn, seed corn, popcorn and sweet corn. The bicyclopyrone mode of action is inhibition of HPPD (4-hydroxyphenyl-pyruvate dioxygenase) enzyme which ultimately causes the destruction of chlorophyll followed by death in sensitive plants. Bicyclopyrone is safe when applied either pre or postemergence to corn and provides pre and postemergence control of grass and broadleaf weeds. Upon registration, SYN-A197 will be the first bicyclopyrone containing product launched with anticipated first commercial application in the 2015 growing season.

BICYCLOPYRONE FOR PRE-EMERGENCE WEED CONTROL IN CORN. Ryan D. Lins*[1], Thomas H. Beckett[2], Scott E. Cully[3], John P. Foresman[4], Gordon D. Vail[4]; [1]Syngenta, Byron, MN, [2]Syngenta, Greensboro, NC, [3]Syngenta, Marion, IL, [4]Syngenta Crop Protection, Greensboro, NC (204)

Bicyclopyrone is a new selective herbicide for weed control in field corn, seed corn, popcorn and sweet corn. The bicyclopyrone mode of action is inhibition of HPPD (4-hydroxyphenyl-pyruvate dioxygenase) enzyme which ultimately causes the destruction of chlorophyll followed by death in sensitive plants. Upon registration, SYN-A197 will be the first bicyclopyrone containing product launched with anticipated first commercial application in the 2015 growing season.  SYN-A197 is a multiple mode-of-action herbicide premix that provides preemergence and postemergence grass and broadleaf weed control. Field trials were conducted to evaluate SYN-A197 for weed control and crop tolerance compared to commercial standards.  Results show that SYN-A197 very effectively controls many difficult weeds and provides improved residual control and consistency compared to the commercial standards.

BICYCLOPYRONE FOR BURNDOWN AND POST-EMERGENCE WEED CONTROL IN CORN. Scott E. Cully*[1], Thomas H. Beckett[2], Ryan D. Lins[3], John P. Foresman[4], Gordon D. Vail[4]; [1]Syngenta, Marion, IL, [2]Syngenta, Greensboro, NC, [3]Syngenta, Byron, MN, [4]Syngenta Crop Protection, Greensboro, NC (205)

Bicyclopyrone is a new selective herbicide for weed control in field corn, seed corn, popcorn and sweet corn. The bicyclopyrone mode of action is inhibition of HPPD (4-hydroxyphenyl-pyruvate dioxygenase) enzyme which ultimately causes the destruction of chlorophyll followed by death in sensitive plants.  Upon registration, SYN-A197 will be the first bicyclopyrone containing product launched with anticipated first commercial application in the 2015 growing season.  SYN-A197 is a multiple mode-of-action herbicide premix that provides preemergence and postemergence grass and broadleaf weed control.   Field trials were conducted to evaluate SYN-A197 for no-till burndown and postemergence weed control and crop tolerance compared to commercial standards. Results show that SYN-A197 very effectively controls many difficult weeds and provides improved residual control and consistency compared to the commercial standards.

DICAMBA + CYPROSULFAMIDE BROADLEAF WEED CONTROL AND TOLERANCE IN CORN. David Lamore*[1], Michael L. Weber[2], James R. Bloomberg[3]; [1]Bayer CropScience, Bryan, OH, [2]Bayer CropScience, Indianola, IA, [3]Bayer CropScience, RTP, NC (206)

*NO ABSTRACT SUBMITTED*

ENLIST™ CORN TOLERANCE AND WEED CONTROL WITH PRE FOLLOWED BY POST HERBICIDE PROGRAMS. Joe Armstrong*[1], Michael Moechnig[2], Scott C. Ditmarsen[3], Mark A. Peterson[4]; [1]Dow AgroSciences, Davenport, IA, [2]Dow AgroSciences, Toronto, SD, [3]Dow AgroSciences, Madison, WI, [4]Dow AgroSciences, Indianapolis, IN (207)

Enlist™ corn has been extensively evaluated in field research trials since 2006 and is anticipated to launch in 2015, subject to regulatory approvals.  Enlist corn, stacked with SmartStax® technology, provides tolerance to both 2,4-D and glyphosate plus above- and below-ground insect resistance.  Enlist Duo™ herbicide is a proprietary blend of 2,4-D choline and glyphosate dimethylamine (DMA) that is being developed by Dow AgroSciences for use on Enlist crops.  Dow AgroSciences will be recommending the use of soil residual herbicides as a part of the Enlist™ Weed Control System to provide early season weed control and crop yield protection along with additional modes of action to manage weed resistance.  Field research trials were conducted in 2013 to evaluate herbicide programs involving Enlist Duo and SureStart™ herbicide (acetochlor + clopyralid + flumetsulam) for weed control and crop tolerance.  Treatments consisted of weed management systems utilizing SureStart applied preemergence (PRE) followed by a postemergence (POST) application of Enlist Duo to V4 corn, SureStart + Enlist Duo applied early POST to V2 corn, or SureStart + Enlist Duo applied POST to V4 corn.  The rate of Enlist Duo in the POST applications was 1640 g ae/ha. The PRE rate of SureStart varied by soil type (1019-1747 g ae/ha) and the POST rate was 1170 g ae/ha.  At 28 days after the V4 application timing, SureStart PRE followed by Enlist Duo POST provided >95% control of glyphosate-resistant waterhemp, common ragweed, and giant ragweed. POST applications of SureStart + Enlist Duo at V2 or V4 also provided >95% control of glyphosate resistant weed species. Crop tolerance ratings were taken 7 and 14 days after the V2 and V4 applications. Visual injury with SureStart applied PRE followed by Enlist Duo at V4 averaged 1% at 7 and 14 days after V4 application. The tank mix of SureStart + Enlist Duo at V2 resulted in an average of 3% and <1% injury at 7 and 14 days after application, respectively. Applications of SureStart + Enlist Duo at the V4 growth stage resulted in 3 and 2% injury at 7 and 14 days after application, respectively. Residual herbicides provide an effective means to prevent yield loss caused by early season weed competition and bring additional modes of action to the weed control program as a component of weed resistance management best practices. These trials demonstrate the utility of residual herbicides followed by POST applications of 2,4-D choline + glyphosate DMA as part of the Enlist Weed Control System in Enlist corn.

®™Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow. Regulatory approvals are pending for the Enlist™ herbicide solution and crops containing Enlist herbicide tolerance traits. The information presented here is not an offer for sale. Always read and follow label directions. ©2013 Dow AgroSciences LLC SmartStax® multi-event technology developed by Monsanto and Dow AgroSciences LLC. SmartStax® and the SmartStax logo are registered trademarks of Monsanto Technology, LLC.

## HPPD RESISTANT PALMER AMARANTH CONTROL WITH PRE AND POST APPLIED HERBICIDES. Curtis R. Thompson*, Dallas E. Peterson; Kansas State University, Manhattan, KS (208)

Palmer amaranth (*Amaranthus palmeri)* (AMAPA) continues to be a serious weed problem in crop production fields in Kansas. Seeds were gathered during the fall of 2009 in Stafford County from AMAPA plants surviving a pyrasulfotole&bromoxynil treatment. Previous work reported on this Stafford County AMAPA population include greenhouse and field dose response experiments showing that populations were 7 to 11 times more resistant to pyrasulfotole and bromoxynil than a known susceptible population. Dose response curves were developed using seed from RXR greenhouse crosses and indicated that rates required to give 50% control were 5.4 g/ha of mesotrione, 4.9 g/ha of tembotrione, and 0.4 g/ha of topramezone resulting in resistance indexes of 54 for mesotrione, 55 for tembotrione, and 63 for topramezone. The objectives of the field experiments in Stafford County, KS were to evaluate PRE and POST applied herbicides for control of the HPPD resistant AMAPA. Herbicides were applied PRE on May 8, 2012 and May 16, 2013 and incorporated with 4 cm of irrigation water. POST herbicides were applied to 15 to 45 cm AMAPA on June 21, 2012 and to 15 to 30 cm AMAPA on June 26, 2013. All treatments were applied with a backpack sprayer delivering 140 L/ha. A second experiment evaluated POST applied mesotrione X=105 g/ha, tembotrione X=92 g/ha, and topramezone X= 18 g/ha at X, 2X, and 4X field use rates applied to 1 to 7 cm AMAPA on May 16, 2013. Results discussed are based on visual evaluations of control. Atrazine at 1.68 kg/ha controlled AMAPA 87 to 88% 3 weeks after treat (WAT) in both years. Additional herbicides applied PRE included isoxaflutole at 105 g/ha with and without atrazine at 1.68 kg/ha, isoxaflutole and thiencarbazone-methyl 2.48:1 at 129 g/ha with and without atrazine at 1.68 kg/ha, acetochlor and atrazine 1.24:1 at 3.6 to 4.2 kg/ha, or S-metolachlor and trazine and mesotrione 10:3.8:1 at 2.77 to 3.34 kg/ha controlled AMAPA 98 to 100% 3 WAT in both years. S-metolachor applied PRE at 0.7 kg/ha in several treatments controlled AMAPA 91 to 98% in 2012 and at 1.1 kg/ha 87 to 93% in 2013. In 2012, mesotrione at 105 g/ha, topramezone at 18 g/ha, tembotrione at 92 g/ha, bromoxynil and pyrasulfotole 5.6:1 at 288 g/ha all applied alone and with 0.56 kg/ha atrazine + 1% V/V COC or MSO and 2.5% V/V urea ammonium nitrate or 1 % w/w ammonium sulfate provided 15 to 41% control of AMAPA 3 WAT. Atrazine at 1.1 kg/ha applied POST controlled AMAPA 11% 3 WAT in 2012 and at 1.68 kg/ha 0% control 3 WAT in 2013. Treatments containing dicamba controlled AMAPA 52 to 61% in 2012 and 2013. Tembotrione at 92 g/ha + atrazine at 1.1 kg/ha controlled AMAPA 7% 3 WAT in 2013. Tembotrione and atrazine tank mixed with dicamba at 420 g/ha increased control to 51% in 2013. Treatments that included K-salt of glyphosate at 1.0 and 1.3 kg ae/ha controlled AMAPA 95 to 98% 3 WAT in 2012 and 2013. The experiment comparing mesotrione, tembotrione, and topramezone suggests that as herbicide rate increased to 4X, control increased. The addition of 0.56 kg/ha atrazine increased control of each herbicide especially at the X and 2X rates. The highest level of AMAPA control (96 to 98%) was attained with 4X rates to the HPPD inhibitors tank mixed with 0.56 kg/ha atrazine. Results from these field experiments suggest that the AMAPA population may be controlled with PRE applied HPPD inhibitors while field use rates of POST applied HPPD inhibiting herbicides are less than effective for managing this population.

## ENHANCEMENT OF THE WEED CONTROL OF PREEMERGENCE SAFLUFENACIL AND DIMETHENAMID APPLICATIONS WITH VARIOUS POST EMERGENCE TIMINGS AND RATES OF PENDIMETHALIN IN GRAIN SORGHUM.

Randall S. Currie*[1], Curtis R. Thompson[2]; [1]Kansas State University, Garden City, KS, [2]Kansas State University, Manhattan, KS (209)

Postemergence broadcast applications of pendimethalin in grain sorghum are currently not labeled for use on sorghum smaller than 4 inches in the High Plains. Work to possibly expand the label was reported in 2010 (Proc. NCWSS 65:120.) This work strongly suggested that pendimethalin applied at spike greatly enhanced grass control of other herbicide tank mixes and increased grain yield. To expand on this work, 2013 studies were conducted at Garden City, KS and Tribune, KS to evaluate weed control and crop tolerance to 1X and 2X rates of pendimethalin applied at three postemergence timings. All treatments included preemergence applications of dimethenamid plus saflufenacil plus atrazine at 0.44 + 0.04 + 1.1 kg/ha followed by postemergence applications of 1.1 or 2.1 kg/ha pendimethalin applied to spike, 2-3 leaf or 12-inch sorghum. This experiment was conducted near Garden City, KS with populations of crabgrass, green foxtail and Palmer amaranth. It was repeated near Tribune, KS under weed free conditions. Experimental design was a randomized complete block with 4 four replications. Within 6 days of any herbicide application, 1 inch of overhead irrigation was applied to insure herbicide incorporation. Post applications of pendimethalin to spike and 2-3 leaf sorghum proceeded by preemergence saflufenacil and dimethenamid provided 3 fold better green foxtail and crabgrass control than the 12-inch timing, regardless of pendimethalin rate. All treatments produced significant levels of Palmer amaranth control compared to the untreated control. Although herbicide treatments were not statistically different, Palmer amaranth control with treatments of saflufenacil and dimethenamid followed by the highest rates of pendimethalin applied at spike and 2-3 leaf stage sorghum produced the highest levels of Palmer amaranth control. No visual above ground sorghum injury was observed at any location. At Tribune, root ratings taken 8 weeks after the last postemergence treatment showed no injury from labeled ratesâ€¨ of pendimethalin. At twice the labeled rates of pendimethalin, the lowest level of root injury was seen with spike applications. The other application timings produced more than 2 fold higher levels of root injury. At Tribune, the highest pendimethalin rate resulted in significantly greater root injury (P=0.05) when applied at 2-3 leaf and 12 inch sorghum, but not at spike. These root ratings did not translate into yield reductions. There were no statistical reductions in yield at the 5% significant level. However, despite the lower levels of root ratings at the 10% significant level the spike applications of pendimethalin at twice the labeled rate reduced sorghum yield 15%. Clearly root ratings were not a good index of yield loss. Although possible injury from pendimethalin is confounded with weed control at the Garden City location, the highest yield was produced with the highest rate of pendimethalin applied at the 2-3 leaf stage. Further, lowest yielding treatments were measured with the latest application of pendimethalin regardless of rate. These treatments also had the poorest level of weed control. Although no visual injury was noted in these trials, in the previous study reported in 2010 the greatest level of injury was observed with this latest pendimethalin application. As was concluded in work done in 2010, this data also indicates that pendimethalin labels should be expanded to include earlier postemergence applications.

---

## HUSKIE COMPLETE - OVERVIEW OF PERFORMANCE IN NORTHERN PLAINS CEREALS.

Kevin B. Thorsness*[1], Steven R. King[2], Dean W. Maruska[2], Michael C. Smith[2], Charlie Hicks[3], George S. Simkins[2], Mark A. Wrucke[2]; [1]Bayer CropScience, Fargo, ND, [2]Bayer CropScience, Raleigh, NC, [3]Bayer CropScience, Fort Collins, CO (210)

Huskie® Complete herbicide is a new postemergence grass and broadleaf herbicide that has been developed by Bayer CropScience for use in spring wheat, durum wheat, and winter wheat. Huskie Complete is a pre-formulated mixture containing the novel active ingredients, thiencarbazone-methyl and pyrasulfotole, with bromoxynil and the highly effective herbicide safener, mefenpyr-diethyl. This unique combination of active ingredients provides consistent broad spectrum grass and broadleaf weed control with excellent crop tolerance. Rapid microbial degradation is the primary degradation pathway for thiencarbazone-methyl and pyrasulfotole in the soil environment and bromoxynil has no soil activity. Therefore, Huskie Complete has an excellent crop rotation profile, allowing re-cropping to most major crops grown in the northern cereal production area. Huskie Complete herbicide was successfully launched in the northern plains cereal production area in 2013. Huskie Complete is specially formulated as a liquid for easy handling and optimized for grass and broadleaf weed control. Apply Huskie Complete at 13.7 fl oz/A after the cereal crop has emerged and up to jointing. Grass weeds should be treated with Huskie Complete between the 1-leaf and 2-tiller stage of growth and broadleaf weeds should be treated between the 1- to 8-leaf stages of growth depending on the species. Huskie Complete herbicide is labeled on 72 different grass and broadleaf weed species with many of them common in the northern cereal production area of the United States. Huskie Complete provides excellent control of key grass and broadleaf weeds such as ACC-ase resistant and susceptible wild oat and green foxtail, yellow foxtail, barnyardgrass, kochia, pigweed sp., wild buckwheat, common lambsquarters, mustard sp., Russian thistle, field pennycress, prickly lettuce, common waterhemp, white cockle, and nightshade sp. Control of sulfonylurea resistant weeds such as kochia, prickly lettuce and Russian thistle biotypes has been confirmed with Huskie Complete in field trials. Additionally, in field trials Huskie Complete has shown excellent control of glyphosate and fluroxypyr resistant kochia. Bromus species, foxtail barley, and quackgrass were effectively controlled or managed with a tankmix of Olympus at 0.2 oz/A in field trials. Huskie Complete has been tested on spring wheat, durum wheat, and winter wheat varieties and crop tolerance was excellent. Broad spectrum grass and broadleaf weed control and excellent crop safety make Huskie Complete a valuable and easy to use tool for cereal grain producers.

## KOCHIA CONTROL IN WHEAT WITH PRE- OR POSTEMERGENCE HERBICIDES. Kirk A. Howatt*, Andrew N. Fillmore; North Dakota State University, Fargo, ND (211)

Some kochia samples demonstrated greater survival than expected when treated in the greenhouse with fluroxypyr as an alternative for controlling glyphosate-resistant kochia biotypes. Preliminary experiments indicated as much as eight-fold resistance to fluroxypyr in North Dakota kochia samples. Therefore, alternatives to sole reliance on fluroxypyr in wheat production were investigated in field experiments for pre- and postemergence herbicides in separate studies. Sulfentrazone at 140 g/ha pre-emergence maintained 99% control of kochia through the entire season. This treatment also resulted in 36% wheat injury expressed as stunting and discoloration, but the response diminished through the first month of exposure and did not result in less wheat grain yield than the maximum obtained. Wheat injury with sulfentrazone at 210 g/ha initially was 50% and resulting grain yield was 19% less than the maximum. Flumioxazin at 70 or 105 g/ha elicited minor injury of 4% that was not noticed 4 weeks after emergence and wheat yield for the treatments provided the maximum value; however, kochia control ranged from 93 to 97%. Postemergence treatments were applied to kochia at a location with demonstrated kochia survival to fluroxypyr in greenhouse screening. Bromoxynil and pyrasulfotole, bromoxynil and fluroxypyr, carfentrazone and fluroxypyr, or fluroxypyr and dicamba provided near complete control of kochia but the highest labeled rate of each treatment was needed. Postemergence treatments tended to give better control in the field than previously experienced in the greenhouse; however, pre-emergence treatments would offer a valuable tool in the management of kochia in wheat.

## MANAGEMENT OPTIONS FOR CONTROL OF GLYPHOSATE RESISTANT KOCHIA IN FALLOW. James R. Bloomberg*[1], Kevin Watteyne[2], Greg Hudec[3], Charlie Hicks[4]; [1]Bayer CropScience, RTP, NC, [2]Bayer CropScience, Lincoln, NE, [3]Bayer CropScience, Manhattan, KS, [4]Bayer CropScience, Fort Collins, CO (212)

The evolution and spread of glyphosate-resistant populations of *Kochia scoparia* in the western United States and Canada is an increasing concern and threat for growers. Since its initial detection in 2007, glyphosate-resistant kochia has now been confirmed in six states including Colorado, Kansas, Montana, Nebraska, North Dakota and South Dakota and also in the Canadian province of Alberta. A recent survey of western Kansas indicates that nearly one-third of the cropland in that area is infested with glyphosate-resistant kochia. There is a need to develop alternative weed control programs to control glyphosate-resistant kochia in the wheat-fallow systems located in the western United States. Two years of field testing confirmed that Corvus Herbicide (isoxaflutole plus thiencarbazone-methyl) applied pre-emergence in combination with PSII inhibitor herbicides such as atrazine or metribuzin can provide excellent residual control of kochia (both susceptible and glyphosate-resistant) populations. These treatments also provide excellent control of *Salsola kali* (Russian thistle) and *Tribulus terrestris* (puncturevine). Postemergence application of Laudis Herbicide (tembotrione) or Huskie Herbicide (pyrasulfotole plus bromoxynil) combined with PSII inhibitors also provide excellent control of kochia, Russian thistle and puncturevine populations but were more erratic in performance than pre-emergence applications due to hot, dry weather conditions experienced at several trial sites. Addition of dicamba or fluoxypyr-based herbicides to the postemergence spray programs improved consistency of weed control. These field studies demonstrate the value of HPPD herbicides for control of glyphosate-resistant kochia and support the importance of utilizing multiple and effective site-of-action herbicides in weed control programs.

## POSSIBLE USE OF INDAZAFLAM FOR FALLOW WEED CONTROL ONE YEAR PRIOR TO PLANTING WHEAT OR CANOLA. Jennifer Jester*[1], Randall S. Currie[2]; [1]Kansas State Univ., Garden city, KS, [2]Kansas State University, Garden City, KS (213)

A trial was established in Finney County Kansas at the Southwest Research and Extension Center near Garden City, KS. Primary application of herbicides was made on September 25, 2012. Combination treatments consisted of glyphosate, metribuzin, indaziflam, and thiencarbazone-methyl with isoxaflutole. All treatments containing preemergence herbicides provided from 90 to 98% control of western tansy mustard (*Descurainia pinnata* [Walter] Britton) 252 days after application (daa). The highest level of control at 98% was achieved with 60 g ae/ha of indaziflam. Drought conditions in addition to absence of irrigation impeded development of most weedy species and made it difficult to determine herbicide activity on the species present. On August 1, 2013 a blanket application of paraquat 620 g ae/ha was made to remove weedy species in an effort to reserve water for fall planting. This application had minimal effect. More than two inches of rain during August was enough to induce a flush of Palmer Amaranth (*Amaranthus palmeri* S. Watson). Treatments with 420 g/ha of metribuzin and 15, 30 and 60 g/ha of indaziflam provided the highest levels of Palmer amaranth control 325 daa. The 30 g/ha level of indaziflam provided the highest level of control at 96%. Escaped kochia (*Kochia scoparia* (L.) A.J. Scott) and Russian thistle (*Salsola tragus* (L.)) were sprayed a second time with burn down treatment of 1540 g ae/ha glyphosate, and 300 g ae/ha each 2, 4-D and pyrasulfotole on August 18, 2013. Canola (B*rassica napus*) and wheat (*Triticum aestivum*) were planted on September 20 and September 23 respectively. Observations of leaf yellowing or stunting were not as pronounced as anticipated. Canola seed depth varied throughout the trial and ratings were delayed in order to determine if canola was slow to emerge due to planting variances or if inhibited by indaziflam. Wheat emergence was not affected and no stunting or discoloration was observed. The highest percentage of injury to canola was observed in the treatment with the highest level of indaziflam. The level of injury for the remaining treatments was comparable to the untreated checks. Plant and root mass in the first replicate indicated that higher levels of indaziflam with metribuzin had greater influence on canola root development.

## PRAIRIE RECONSTRUCTION: A WEED IS A WEED IS A... PLACEHOLDER? Diane L. Larson*; U.S. Geological Survey - Biological Resources Division at Northern Prairie Wildlife Research Center, Minneapolis, MN (214)

One of the benefits of ecological restoration is often considered to be sustainable weed management. Principles of resource availability often guide our restoration strategies. By installing a diverse suite of native plant species to effectively monopolize resources, invasion should become more difficult. What we sometimes fail to recognize is that the early successional “weedy” native species that inevitably arise from the seed bank also have a role to play in reducing invasion by exotic species. Legacies of prior infestations, which may include changes to both below-ground mutualists and pathogens, can result in seemingly inexplicable lack of establishment of some species. However, if we understand the variation among plant species in their responses to soil legacies, we can use this to our advantage to gradually rehabilitate a degraded site. Finally, ecological functions performed by an exotic species need to be considered before it is eliminated during restoration of a site. The target exotic may have replaced the functions performed by the native it displaced, or it may have developed entirely new ecological relationships that support desirable or vulnerable native species. An improved understanding of interactions among native and exotic plants and their above- and below-ground mutualists and enemies can increase the likelihood of sustainable restoration and weed management.

## CHEMICAL EXPLANATIONS FOR THE IMPACTS OF INVASIVE PLANTS: HOW IMPORTANT ARE THEY? Don Cipollini*; Wright State University, Fairborn, OH (215)

*NO ABSTRACT SUBMITTED*

WHAT'S NEW IN INVASION BIOLOGY, AND WHY IS IT CONTROVERSIAL? Daniel Simberloff*; University of Tennessee, Knoxville, TN (216)

Modern invasion biology is a young field, having begun in the 1980s. Research during the first two decades focused largely on the impacts of particular invasive species on particular native species. Such work continues to be important, because impacts of the great majority of introduced species have not been studied. However, in this century the field has expanded greatly in three main directions. First, an increasing number of studies document ecosystem-wide impacts of particular invasions, by virtue of changed nutrient, hydrological, or fire regimes or modified physical structure. Second, the role of evolution in invasions has become a major object of research. Finally, management of invasive species has become increasingly integrated into invasion biology. Along with the explosive growth of the field has come a series of controversies, especially over how many and to what extent non-native invaders are really harmful, whether it is hopeless to try to stem an increasing tide of invaders, and whether fighting non-native species is somehow xenophobic. A parallel and related controversy has simultaneously arisen in restoration, with some practitioners arguing that we should abandon traditional efforts to restore damaged sites to a semblance of a reference condition so they can evolve as they were before human disturbance. Rather, in this view, ecological “restoration” should not aim to restore anything, but rather to turn inevitable “novel ecosystems” to human advantage, for instance by providing ecosystem services.

THE MIDWEST INVASIVE PLANT NETWORK'S CONTROL INFORMATION DATABASE: A RESOURCE FOR NATURAL RESOURCE MANAGERS AND LANDOWNERS. Katherine M. Howe*[1], Brendon J. Panke[2], Mark J. Renz[2]; [1]Purdue University, Indianapolis, IN, [2]University of Wisconsin-Madison, Madison, WI (217)

The Midwest Invasive Plant Network (MIPN) and the University of Wisconsin-Madison have developed a searchable, on-line invasive plant control database. The database includes control and identification information for over 40 invasive species. Both chemical and non-chemical control techniques are presented, and each control method has ratings for its effectiveness during the year of treatment and the year after treatment. This database contains information on control methods that are either common or effective at controlling specific invasive plants in the Midwest. Methods that are uncommon, do not provide sufficient control, or lack information for determining effectiveness on target species are omitted. The database also allows users to enter information on their experiences with control efforts for the invasive species in the database by submitting a case study. This database provides a central platform for the entire region to easily access and share control information.

GLEDN: HOW TO REPORT INVASIVE PLANT LOCATIONS AND SIGN UP FOR ALERTS. Mark J. Renz*, Brendon J. Panke; University of Wisconsin-Madison, Madison, WI (218)

The Great Lakes Early Detection Network (GLEDN) was developed to facilitate rapid response to invasive species by sharing invasive species locations in the Great Lakes region. GLEDN developed the Global Invasive Species Information Network which allows data providers (e.g. MISIN, EDDMaps) to share invasive species location information. By sharing data, a more complete map of distribution can be created and allow data providers to deliver early detection alerts to local stakeholders. If existing locations do not use a data provider, GLEDN offers this feature as well as the ability for citizens to enter new observations through the website or a mobile application. To date over 750,000 invasive species locations have been added by more than eight data providers. In addition, citizens have contributed over 650 observations directly to GLEDN. This presentation will demonstrate how to use GLEDN so that you can start adding to the regional dataset and help combat the spread of invasive species in Ohio as well as the Great Lakes region.

TRACKING INVASIVE SPECIES: WE HAVE AN APP FOR THAT! Kathy Smith*; Ohio State University Extension, Columbus, OH (219)

An important part of managing invasive species issues is gaining a firm understanding of the extent of the problem. Many times the information surrounding an infestation is based solely on anecdotal information. The challenge for managers becomes how to get a better handle on what is where! By utilizing smart phone technology and apps like the Great Lakes

Early Detection Network (GLEDN), citizens can join land managers to become stakeholders in the early detection race. This app is used to help track plant, insect, disease, aquatic and wildlife invasive species issues and was created with the help of The University of Georgia's Center for Invasive Species and Ecosystem Health. Ohio State University Extension is training Master Gardener and Volunteer Naturalist volunteers to use the app in order to help us get a better handle on the extent of some of the invasive species issues in the state. Woodland owners and natural resource land managers across the state have also been trained to use the app so that they too become more aware of the non-native invasive species issues that may be on the horizon and what to do if they suspect they have found one. This app is designed to cover the Great Lakes region and is a great example of how to utilize today's technologies to help fight an ever increasing land management issue - non-native invasive species. It has also proven to be an excellent way of engaging the public and raising their awareness of these issues.

IMAPINVASIVES - AN EMERGING ONLINE REPORTING TOOL FOR EARLY DETECTION RAPID RESPONSE. Amy Stauffer*; Western PA Conservancy, Pittsburgh, PA (220)

*NO ABSTRACT SUBMITTED*

COMMUNICATING HYDRILLA SEARCH EFFORTS IN NEW YORK: USING IMAPINVASIVES WITH PROFESSIONALS AND VOLUNTEERS. Jennifer M. Dean*; NY Natural Heritage Program, Albany, NY (221)

*NO ABSTRACT SUBMITTED*

REACHING CONSUMERS: SMART PHONE APP FOR LANDSCAPE ALTERNATIVES FOR INVASIVE PLANTS. Lara A. Vallely*[1], Katherine M. Howe[1], Mark J. Renz[2], Chuck Bargeron[3]; [1]Purdue University, Indianapolis, IN, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Georgia, Tifton, GA (222)

The Midwest Invasive Plant Network creates tools for invasive plant prevention, early detection, education and outreach, and control and management. The Landscape Alternatives smart phone app is a prevention and education tool that gives consumers information to make informed plant purchases. The app provides a dynamic and convenient means to connect with the gardening public about alternatives to invasive plants. This talk will provide context for the need for invasive plant prevention, a summary of the information available in the app, and an overview of how to use the app.

UPDATE ON GREEN INDUSTRY OUTREACH EFFORTS IN THE MIDWEST. Cathy A. McGlynn*; Northeast Illinois Invasive Plant Partnership, Glencoe, IL (223)

The Northeast Illinois Invasive Plant Partnership, the Midwest Invasive Plant Network, and several other partners are collaborating on multiple projects designed to increase public awareness among green consumers and develop a relationship with green industry suppliers and nurseries/garden centers in the Midwest. This talk provides updates about new resources and outreach efforts that are reaching hundreds of people throughout the region: smartphone application, video documentary, invasive ornamental workshops and exhibits, bilingual educational materials, and a symposium and working group.

GO BEYOND BEAUTY: COMMUNITY-BASED SOLUTIONS FOR WORKING WITH NURSERIES TO REMOVE INVASIVE ORNAMENTAL PLANTS FROM TRADE. Mathew Bertrand*; Michigan State University, Suttons Bay, MI (224)

Join the Northwest Michigan Invasive Species Network (ISN) for a report on their efforts toward whole-community engagement in invasive plant management. Learn about Go Beyond Beauty, ISN’s successful effort to engage nursery and landscape professionals in invasive plant management by removing key species from the local trade. Hear about research, setup, and implementation of the program, then get a preliminary recap of the first year, hear our plans for next year, and help brainstorm dreams for the future.

CULTIVATING AWARENESS: USING VIDEO TO DEMONSTRATE THE IMPACTS OF INVASIVE ORNAMENTAL PLANTS IN NATURAL AREAS. Katherine M. Howe*[1], Mark J. Renz[2], Brendon J. Panke[2], Cathy A. McGlynn[3]; [1]Purdue University, Indianapolis, IN, [2]University of Wisconsin-Madison, Madison, WI, [3]Northeast Illinois Invasive Plant Partnership, Glencoe, IL (225)

Horticulture is a major pathway for the introduction of invasive species into natural areas and one of the most challenging to control. Often, people who grow, sell, and plant ornamental plants do not know or believe that particular species are invasive, because they have never seen infestations in natural areas.  We created a video documenting the invasions of *Rhamnus cathartica* (common buckthorn), *Euonymus alatus* (burning bush), *Berberis thunbergii* (Japanese barberry), and *Pyrus calleryana* (Callery pear) into natural areas in the Midwest to use in outreach to green industry and consumers about the impacts of these species on native species and ecosystems.  The video is available to partner organizations that would like to use it for their own outreach programs.

SUCCESSFUL PHRAGMITES CONTROL IN NORTHEAST OHIO WATERSHEDS. Karen Adair*; The Nature Conservancy, Rock Creek, OH (226)

From small to large scale, populations of Phragmites australis can be efficiently and effectively controlled with proper planning, treatment, and commitment. Sustained success requires a solid understanding of Phragmites physiology; how to prioritize invaded areas; what strategies work best; selection of control methods and herbicide application; and the scale-appropriate resource commitment. The Nature Conservancy has recently worked on a number of large-scale Phragmites control projects throughout northern Ohio and will share our approaches and lessons learned.

MANAGEMENT OF INVASIVE WOODY VINES. Chris W. Evans*; Illinois Wildlife Action Plan, Marion, IL (227)

Management of invasive woody vines present challenges to land managers.  Root suckering, climbing into trees, and multiple rooting sites all enhance the invasiveness of these species, add complexity when applying control techniques, and increase the chances of non-target impacts.  However, when using the correct application techniques, these species can be safely and effectively managed.  This presentation will cover identification and control of several woody invasive plants including Oriental bittersweet, Japanese honeysuckle, and kudzu.  Non-woody vines, such as mile-a-minute and Chinese yam will also be included.

BIOLOGY AND CONTROL OF AILANTHUS. Eric Boyda*; Appalachian Ohio Weed Control Partnership, Pedro, OH (228)

The adaptability of the invasive tree *Ailanthus altissima* (tree-of-heaven) to a variety of site conditions has led to the vast spread of the species throughout the United States. The destructive nature of *A. altissima* is noticed ecologically and economically (natural resources and infrastructure). Despite this noticeably aggressive behavior, *A. altissima* identification can often be confused with native species including sumacs (*Rhus* spp.) and walnuts (*Juglans* spp.). Control of *A. altissima* can often be difficult if not administered correctly pending control method, plant size, and time of year. This presentation will explain the general biology, identification, and control techniques that can help land owners and managers control *A. altissima*.

ASSESSING AND PREDICTING THE RISK OF NON-NATIVE PLANT INVASIONS IN FLORIDA'S NATURAL AREAS. Deah Lieurance*[1], S L. Flory[2]; [1]UF/IFAS Assessment, Gainesville, FL, [2]University of Florida, Gainesville, FL (229)

Detrimental effects of non-native invasive plants, including reduced biodiversity, ecosystem function, and alteration of fire regimes, are especially evident in the natural areas of Florida. Detection, monitoring, and management of invasions cost the state millions of dollars per year. Thus, preventing high-risk species from being released into natural areas and managing invasive species early in the invasion process can reduce ecological and economic impacts. To identify species most likely to invade and cause damage in Florida’s natural areas, the University of Florida’s Institute of Food and Agricultural Sciences (IFAS) developed The IFAS Assessment of Non-Native Plants in Florida’s Natural Areas (hereafter IFAS Assessment). The purpose of the IFAS Assessment was to provide UF faculty and staff a common basis for descriptions of non-native plant species in Florida and recommendations for their use and management. The IFAS Assessment is composed of three components: the Status Assessment to evaluate resident species already present in the state of Florida, the Predictive Tool to evaluate species new to the state or proposed for a new purpose (e.g., biofuels), and the Infraspecific Taxon Protocol (ITP) to evaluate cultivars, varieties, and subspecies independently from resident species. To date, over 780 species have been evaluated with at least one of the IFAS Assessment components. Over the last two years 25 new species were assessed after detection in natural areas (or were proposed for new uses) and status reassessments resulted in the amendment of conclusions for 104 species. The success of the IFAS Assessment is largely dependent on information that is queried from the land management and scientific communities who are willing to donate their time to assist in the evaluation process. In return, we hope that the synthesis of our efforts can benefit the natural areas of Florida and assist in prioritization of management efforts.

ASSESSING INVASIVE PLANTS IN OHIO: THE PROCESS AND PROGRESS OF THE OHIO INVASIVE PLANTS COUNCIL ASSESSMENT PROGRAM. Theresa M. Culley*; University of Cincinnati, Cincinnati, OH (230)

In order to update the list of invasive plants in Ohio that was created well over a decade ago, the Ohio Invasive Plants Council (OIPC) began in 2008 to develop a scientifically-based protocol for assessing invasiveness in introduced plant species and cultivars. This two-step protocol contains an initial step of four questions to efficiently identify plants already recognized as noxious or those plants well-supported by scientific evidence as being invasive. The second, more-detailed step consists of 18 questions focusing on traits widely recognized in the scientific literature as associated with invasiveness. Over a year ago, an assessment team representing researchers, land managers, nursery professionals and other stakeholders of the OIPC began meeting regularly to assess selected plants. We report here the results for the first group of assessed species specifically chosen to represent a variety of plants in Ohio: those typically recognized as invasive, newly spreading species whose status had not yet been characterized, and plants generally not considered to be problematic. Many of the plants identified by the assessment team as 'Invasive' currently are listed as such for Ohio; these include Amur honeysuckle (*Lonicera maackii*), garlic mustard (*Allaria petiolata*), and Autumn Olive (*Elaeagnus umbellata*). However, some plants that had never before been assessed in Ohio, such as Japanese stiltgrass (*Microstegium vimineum*) and lesser celandine (*Ranunculus ficaria*), were also identified as 'Invasive'. As expected, naturalized species such as dandelion (*Taraxacum officinale*) and broad leaf plantain (*Plantago major*), ranked as 'Not Invasive', supporting the validity of the assessment protocol. Overall, these initial results of the assessment protocol were consistent with rankings from surrounding states.

ASSESSMENT OF INVASIVE SPECIES IN INDIANA'S NATURAL AREAS. Ellen Jacquart[1], Katherine M. Howe*[2]; [1]The Nature Conservancy, Indianapolis, IN, [2]Purdue University, Indianapolis, IN (231)

In 2003, Indiana’s Invasive Species Assessment Working Group (IPSAWG), a group of conservation practitioners and green industry professionals, developed an assessment tool to determine which species threaten natural areas in Indiana. They focused only on invasive plants in trade and created recommendations for the use of those species. IPSAWG completed 25 assessments, designating species as high, medium, or low threats to Indiana natural areas. In 2010, the Indiana legislature created the Indiana Invasive Species Council, and the task of assessing invasiveness of plants was transferred to the Council’s Invasive Plant Advisory Committee (IPAC). IPAC’s focus has broadened to include all potentially invasive plants, not just those currently being sold, with the goal of creating a comprehensive invasive plant list for the state of Indiana. As of November 2013, there are 87 species on the invasive plant list, plus an additional 7 species on the caution list. Caution species are plants for which there is not enough information to definitively determine their threat level. IPAC's assessment process is on-going, and they are currently reviewing their assessment protocol to improve their ability to predict whether new species have a high likelihood of becoming invasive in the future.

STANDARDIZING THE CREATION OF INVASIVE PLANT LISTS. Susan Gitlin*; US Environmental Protection Agency, Washington, DC (232)

Under the auspices of ASTM International, members of Exotic Pest Plant Councils (EPPCs) are developing a standard for listing invasive plants. Such a standard is intended to help organizations, including EPPCs, prepare strong, transparent lists that can be used in more formal ways, such as being referenced in state and local building codes that aim to reduce the use of invasive plants in landscaping. The impetus for the creation of this standard was the increase in green building and landscaping programs that discourage the use of invasive plants. Such programs are often dependent on a generally-accepted list of definition of invasive plants; it became apparent that no widely recognized science-based protocol exists that creates a common basis for listing what is and is not invasive to a given area. The ASTM task group is using the criteria and procedures that are common to approaches used by EPPCs as the foundation for the new standard.

INVASION DYNAMICS OF AMUR HONEYSUCKLE IN SOUTHWEST OHIO. David Gorchov*, Mary Henry; Miami University, Oxford, OH (233)

Understanding the patterns and processes shaping a biological invasion has the potential to inform management, for example by identifying sites that are at greatest risk of invasion or suggesting an efficient strategy for slowing invasion. We investigated the invasion of Amur honeysuckle, *Lonicera maackii*, a shrub from east Asia, in woodlots in an agricultural landscape of southwest Ohio. To explore the relative importance of community invasibility vs. propagule rain in determining which woodlots are invaded, we investigated how well stand vs. landscape characteristics explained *L. maackii* cover. We hypothesized younger stands were more susceptible to invasion, but found stand age was not an important predictor of *L. maackii* cover, nor were other woodlot parameters such as woodlot size or tree basal area. Instead, *L. maackii* cover in woodlots was due primarily to the composition of the landscape in a 1500 m buffer around the woodlot. Specifically, woodlots surrounded by more cropland had less *L. maackii* cover. We attribute this pattern to the paucity of nearby seed sources and/or minimal movement of birds and mammals that are the seed dispersal agents. We conclude that impediments to seed arrival (propagule rain) are more important in shaping the invasion of this exotic shrub, than are characteristics of the woodlots themselves (invasibility). To further investigate the importance of propagule rain in population growth, we used the age structure of populations to infer the contribution of external propagule rain vs. within-population reproduction. We quantified the age structure of 14 populations of *L. maackii* in a landscape where it recently invaded in Darke County, Ohio. We sampled the largest *L. maackii* individuals in each population (woodlot) and aged these by counting annual rings. Individuals in the oldest four age classes were assumed to be from external recruitment, given the minimum age of reproduction. We used these recruitment rates to model external recruitment over the next five years, used observed age structures to estimate total recruitment, and compared these values to infer internal recruitment. Our findings indicate that recruitment from within the population is of about the same magnitude as immigration in years 5-7 after population establishment, but by years 8-9 internal recruitment dominates. At the landscape scale, the temporal-spatial pattern of population establishment supports a stratified dispersal model, with the earliest populations establishing in widely spaced woodlots, about 4 km from existing populations, and these later serving as 'foci' for diffusion to nearby woodlots. Thus dispersal events that initiate populations come from relatively distant (4 km) as well as closer sources, and populations grow due to both immigration and in-situ reproduction. These findings suggest that invasion can be slowed if these foci can be located and the plants removed, but this alone will not stop the diffusion from established populations.

## SPECIES INFLUENCES ON ECOSYSTEMS PROCESSES: CONTEXT-DEPENDENT IMPACTS OF THE INVASIVE *LONICERA MAACKII*.

Sarah Bray[1], Megan Poulette[2], Mary A. Arthur*[3]; [1]Transylvania University, Lexington, KY, [2]Cornell College, Mt. Vernon, IA, [3]University of Kentucky, Lexington, KY (234)

*NO ABSTRACT SUBMITTED*

## AMUR HONEYSUCKLE INTERACTIONS WITH POLLINATORS: CONSEQUENCES FOR REPRODUCTION OF BOTH INVADER AND NATIVE PLANTS.

Karen Goodell*; Ohio State University, Newark, OH (235)

Plants that invade new locations must establish mutualistic links in their new region. The success with which these links are established will help determine reproductive output, mating patterns, and genetic variability, which will in turn contribute to rates of spread and potential for local adaptation and evolutionary change. Newly established mutualistic interactions could also impact the populations of mutualists, such as pollinators, and thus exert indirect effects on the mutualisms of native plants growing nearby. While some of those interactions, such as competition for pollinators, are detrimental to the reproduction of native species, others could be neutral or even beneficial, such as facilitation of pollination. Furthermore, the local-scale abiotic and biotic context in which these new interactions play out can affect the magnitude and direction of effects. Assessing the impact of the invader and the consequences of its removal should take into account as many of these interactions and contexts as possible. *Lonicera maackii* is a prolific invasive shrub in forests and open areas of Ohio and parts of the Midwest and it dominates floral communities in May. Research in my lab has investigated how the interactions between an *L. maackii* and pollinators affect both its own reproduction and reproduction of native plants. Hand pollination experiments showed that *Lonicera maackii* depends on pollinators and that pollination consistently limited seed production. The extent of pollen limitation depended on environmental factors such as light and plant density, factors that also influenced the species identity of pollinators and pollinator behavior. Several experiments investigated the potential for *L. maackii* to compete for pollinators with native plants. In one experiment, we tried to isolate the effect of flowers over the effect of shading by foliage on pollination services to natives. By comparing pollinator visitation to potted native plants near *L. maackii* shrubs with only flowers removed, all above ground vegetation removed, or a control, we found that *L. maackii* with only leaves and no flowers suppressed pollinator visitation to sentinel native plants as much as plants with flowers, indicating negative effects on pollination, but little competition for pollinators. We also found no evidence that native plants along the heavily invaded forest edge competed for pollinators with *L. maackii,* but as distance from the forest increased, native plants received fewer visits and became more pollen limited, suggesting that at larger spatial scales *L. maackii* aggregates pollinators and depletes their abundance in surrounding habitat. Phenological overlap of flowering with the invader was also important in determining the outcome of interactions mediated through pollinators. In areas where *L. maackii* co-flowered with *Hydrophyllum macrophyllum*, the latter appeared to receive more pollinator visits than in a location where the two did not co-flower. These findings complicate the classification of this invasive species as “harmful” or “benign”, but provide insights into its ecological role that could guide control and management strategies.

## MANAGEMENT OF AMUR HONEYSUCKLE IN HAMILTON COUNTY OHIO PARKS: A CASE STUDY.

Tom Borgman*; Great Parks of Hamilton County, Cincinnati, OH (236)

**Introduction** The Great Parks of Hamilton County, (GPHC), manages more than 16,560 acres in the southwest corner of Ohio. Most of the district’s 20 parks and preserves are covered by second growth or successional hardwood forest. About 5% of park natural area is comprised of tall grass prairie or cool season grassland. Six percent of the total acreage has wetland or aquatic ecosystems. In her book *The woody plants of Ohio: trees, shrubs and woody climbers, native, naturalized and escaped,* (1961 Ohio State University Press), E.L. Braun stated that Amur honeysuckle was “Reported only from Hamilton County, where it is becoming abundant in pastures and woodlands*”.* Fifty years later, much of that invaded land is park property. About 4,000 acres of GPHC has at least 20% cover of non-native bush honeysuckle.

**Criteria used to prioritize invasive plant control locations** *First priority:* 1) Easy access. Edges of roads and fields allow larger spray equipment to reach target plants. This provides the most acreage controlled of the plants that produce most of the seed. There is also immediate savings of time that would be spent trimming these plants. Native plants that replace the exotics are usually not as aggressive, so require much less maintenance. 2) High use areas. This provides the park guests with the benefits of more diverse plant life and a more visually appealing view. 3) High quality natural area, rare species. Removing invasive species protect and promotes plants and animals of special interest and their environment. 4) Availability of resources. When volunteers or other opportunities arise, we take advantage of it. 5) Completion of whole parks or sections within a park. 6) Maintain treated sites. Once an area is sprayed, occasional touch up is required to keep invasive species from returning. 7) Stop the spread of new threats. If a species has been proven to be very invasive elsewhere, we will eliminate it from our parks to keep it from being the “next Honeysuckle”. *Second priority:* Other lower quality natural areas. Remote, less significant natural areas will be worked on if time allows. Some areas may never be reached.

**Methods and Materials 1)** *Pull or dig.* When a sparse population of small honeysuckle occurs in a wooded area, and it is not a good time to apply herbicide, we pull the honeysuckle and hang the roots to dry. If volunteer help is available, pulling or digging is an option. This method creates the most soil disturbance, and is the most labor intensive. We remove about ½ acre of honeysuckle per year this way. 2) *Basal bark treatment.* Apply an herbicide with a penetrating oil carrier to the base of each shrub. This can be done any time the bark is dry. Even when applied in winter there is some residual affect on non- target species. We use Pathfinder II, a ready to use formulation with Garlon 4 as the active ingredient in non-petroleum oil penetrant. We control about 2 acres per year by basal bark treatment. 3) *Cut and treat stumps* Cut honeysuckle off close to the ground then spray or paint a 33% solution of glyphosate to cut surface. We cut about 15 acres of honeysuckle each year. This is a good project for volunteer groups. 4) *Cut or mow then spray leaves the following fall.* If large mowing equipment is used to cut down honeysuckle, instead of trying to find stumps under all the cutting and chips, we wait till it grows back then use a foliar application of 1.25% glyphosate in the fall. 5) *Fall foliar application of glyphosate* Spray honeysuckle with 1.25% glyphosate after desirable species are no longer green and when the honeysuckle is continuing photosynthesis. We controlled more than 3600 acres using this method since 2004.

**Average costs of several honeysuckle control methods in the Hamilton County Parks** 1) Contracted foliar treatment: $320 per acre; 2) Contracted cut and chip brush: $3200 per acre; 3) Contracted brush mowing: $900 per acre; 4) In house foliar treatment: $150 per acre plus equipment expenses; 5) In house cut and treat stumps: $1200 per acre.

**Results and Discussion** The Great Parks of Hamilton County began controlling honeysuckle more than 20 years ago. At that time the method of choice was to dig it up with a pick and shovel. It was very labor intensive and caused a lot of soil disturbance. We also would just cut it off at the ground. The results were that each cut stem would sprout into three or more stems. Much has been learned since then about controlling Amur honeysuckle and other invasive plants. By far the most efficient way to control honeysuckle is fall foliar treatment. The question some people have is, is it worth all the effort? We think it is. The park district supports research and monitoring of invasive species, their control and their effect on the ecosystem. Our research and observations have shown that native species diversity and density increase after honeysuckle management.

**Acknowledgements** We would like to thank Dr. Donald R. Geiger for introducing us to the fall foliar application of glyphosate to control Amur honeysuckle.

## PLANT-HERBIVORE INTERACTIONS AND THE INVASION OF AMUR HONEYSUCKLE IN NORTH AMERICA.

Deah Lieurance*; UF/IFAS Assessment, Gainesville, FL (237)

The Enemy Release Hypothesis (ERH) argues that when a species is introduced to a novel habitat, it benefits from a release from co-evolved pathogens/herbivores, particularly specialists, present in their native range resulting in increased vigor, abundance, and distribution. Additionally, invasive plants must also escape or resist herbivores that affect closely related congeners in the introduced range. We conducted a variety of field, common garden, and laboratory experiments to investigate some assumptions of ERH and to search for differences in resistance traits between native and non-native *Lonicera* species. Invasive *Lonicera* species appeared to benefit from the absence of arthropod herbivores in North America while native *Lonicera* growing in field and common garden conditions incurred considerable damage. Observations indicated that non-native *Lonicera maackii* received less than 5% defoliation across multiple seasons. A model generalist herbivore performed better on non-native *Lonicera*, and *Zaraea inflata*, a honeysuckle specialist herbivore, performed better on native foliage in laboratory feeding assays. *Lonicera reticulata* was heavily damaged in the field by the same specialist herbivore, but did not feed on *L. maackii* in the field even though it was able to reach pupation in the laboratory. Multivariate chemical profiling of native and non-native *Lonicera* species indicated there was variation in quantity and composition of selected defense compounds by species, but geographic origin was an inconsistent predictor of variation. Specific resistance traits, escape through behavioral avoidance, or a combination of both may contribute to reduced herbivory and competitive advantages for *L. maackii* and other non-native *Lonicera* in North America.

"THE PLAN TO WIN" AMUR HONEYSUCKLE REMOVAL AND RESTORATION IN THE FIVE RIVERS METROPARKS. Mary Klunk*; Five Rivers MetroParks, Dayton, OH (238)

The Five Rivers Metro Parks has been actively removing invasive plants including Amur honeysuckle since the mid to late 90's. There has been an evolution of techniques used over the years from hand pulling, cutting and chipping, basal herbicide application and high volume herbicide application. Based on cover mapping data collected in 2000 and the effectiveness of the high volume herbicide application method conservation staff thought it might be possible to drastically reduce or eliminate Amur honeysuckle from our parks in the Twin Valley, approximately 2700 acres. In 2007 the "Plan to Win" was developed and implementation began in 2008 through 2013. Over the past six years staff, contractors and volunteers have removed or treated hundreds of acres of honeysuckle in the Twin Valley. We have also planted thousands of native trees and shrubs to fill in the gaps left by the dead honeysuckle. The question to be addressed in this presentation is "Are we winning"?

RIPARIAN ZONE INVASION OF AMUR HONEYSUCKLE ALTERS HEADWATER STREAM BIOTA AND ECOSYSTEM FUNCTION. Rachel E. McNeish*, Mark E. Benbow, Ryan W. McEwan; University of Dayton, Dayton, OH (239)

*NO ABSTRACT SUBMITTED*

COMPREHENSIVE SYSTEM FOR CONTROLLING AMUR HONEYSUCKLE. Donald Geiger*; Univ. of Dayton, Dayton, OH (240)

*NO ABSTRACT SUBMITTED*

INFERRING INVASION PATTERNS OF *LONICERA MAACKII* IN SOUTHWESTERN OHIO FROM THE GENETIC STRUCTURE OF ESTABLISHED POPULATIONS. Oscar J. Rocha*; Kent State University, Kent, OH (241)

We investigated the genetic structure of 41 populations of the invasive shrub *Lonicera maackii* (Amur honeysuckle), including an area where populations have only recently established and nearby potential source populations in southwest Ohio and adjacent Indiana. We used six polymorphic microsatellite markers to describe the genetic structure of this shrub. We found total of 93 alleles across the six loci examined. High levels of allelic diversity were found across all populations, with the actual number of alleles ($N_a$) and effective alleles ($N_e$) per locus equaling 8.13 and 4.79. Our results also revealed high levels of heterozygosity across all loci and all populations, and low to moderate levels of genetic differentiation among populations, with low inbreeding, and moderate gene flow. An Analysis of Molecular Variance (amova) showed that only 10% of the variance was attributed to the differences between populations. The program Structure revealed that four is the most likely number of clusters (*K*) to describe the genetic relationship among these 41 populations of *Lonicera maackii*. The one cluster represents a group that dominates in the southwest portion of Darke County. A second cluster is more abundant in the northwest portion of Preble County. A third cluster is dominant in the southeastern portion of the study area, including Hamilton Butler, southern Preble and Montgomery counties. An additional cluster was identified among the most northern populations. This information is used to make inferences about invasion pathways and the relative importance of diffusion vs. long-distance dispersal mechanisms in the spread of *L. maackii* in the area.

RECOVERY OF FOREST COMMUNITIES AFTER AMUR HONEYSUCKLE REMOVAL. Richard L. Boyce*; Northern Kentucky University, Highland Heights, KY (242)

*Lonicera maackii* (Amur honeysuckle) is one of the most important invasive plants in the Ohio Valley. Because of its phenology and dense canopy, it can exclude native herbs and interfere with regeneration of woody plants. I established modified 1000-$m^2$ Whittaker plots with nested subplots in four stands in a county park in southwest Ohio with a gradient of *L. maackii* cover in 2005. The *L. maackii* canopies were removed by herbicides in fall 2005. Plant cover was monitored from 2005 to 2013. After eight years, there was an increase in species richness at all sites. Until 2009, species richness increased from ~50 to 80-85 species at all sites except for one with the least amount of initial honeysuckle cover, which has stayed at ~50-55; since then, the other sites first declined but then increased. Herbaceous cover increased by at least a factor of two at all of sites, and the number of both native and invasive species increased. Garlic mustard (*Alliaria petiolata*) cover initially increased after honeysuckle removal but has since declined, suggesting that its initial surge after *L. maackii* removal may be transitory. Honeysuckle removal from the understory can lead to recovery of the native plant community in upland forests, although desirable results can take some time (≥ 8 years), especially when initial honeysuckle coverage is high. However, the recent decline of ash (*Fraxinus spp.*) due to the exotic emerald ash borer (*Agrilus planipennis*) has introduced a major disturbance that may now alter the recovery of native vegetation after honeysuckle removal. On the other hand, honeysuckle leaf blight, caused by the basidiomycete *Insolibasidium deforman*, was present at all sites, and this may decrease the ability of *L. maackii* to take advantage of canopy openings created by the ash decline.

A PRICE TO PAY FOR RESTORATION? SOIL LOSS ASSOCIATED WITH AMUR HONEYSUCKLE REMOVAL IN OLMSTED PARKS OF LOUISVILLE, KY. Margaret M. Carreiro*[1], Major Waltman[2]; [1]University of Louisville, Louisville, KY, [2]Louisville Olmsted Parks Conservancy, Louisville, KY (243)

Protecting soils is a challenge for natural areas managers, particularly in urban park woodlands where recreational use, and exotic species and their management can alter the soil's physico-chemical characteristics, biota and processes. Several experiments have been conducted primarily in the woodlands of Cherokee Park, Louisville, KY focused on the effects of shrub honeysuckle and its management on litter dynamics and the ability of shrubs and litter to reduce soil loss on wooded slopes. In prior experiments we found that compared with low-density honeysuckle plots in woodlands, high-density honeysuckle plots exhibited reduced canopy litter inputs, and faster litter decay due in part to greater macroinvertebrate activity. These factors suggest that slopes colonized by honeysuckle will be more vulnerable to soil loss by summer when rainfall is most intense. Therefore, over 13 months, we measured soil loss monthly at three sites varying in slope, each containing shrub (control), shrub removal, and litter and shrub removal plots. We found that soil losses were greatest in summer when leaf litter mass was lowest. Shrubs alone prevented as much as 5 metric tons/ha of cumulative soil loss per year, but litter (primarily fine woody debris by summer) prevented as much as 34 metric tons/ha per year of soil loss. Managers need to be aware of the importance of maintaining fine woody debris on slopes the first year after shrub removal to reduce soil erosion.

# Keyword Index

# Author Index

# North Central Weed Science Society Information

## 2013 Officers/Executive Committee

**President**

| | |
|---|---|
| Dave Johnson | Du Pont Pioneer |

**President Elect**

| | |
|---|---|
| J.D. Green | University of Kentucky |

**Vice President**

| | |
|---|---|
| John Hinz | Bayer CropScience |

**Past President**

| | |
|---|---|
| Bryan Young | Southern Illinois University |

**Secretary/Treasurer**

| | |
|---|---|
| David Simpson | Dow AgroSciences |

**Editor, NCWSS Proceedings**

| | |
|---|---|
| Bob Hartzler | Iowa State University |

**Editor, NCWSS Communications**

| | |
|---|---|
| Harlene Hatterman-Valenti | North Dakota State University |

**WSSA Representative**

| | |
|---|---|
| Mark Benards | Western Illinois University |

**CAST Reprentative**

| | |
|---|---|
| Curtis Thompson | Kansas State University |

**Executive Secretary**

Phil Banks, 575-527-1888,
ncwss@marathonag.com

## Sustaining Members

ABG Ag Services
AMVAC Chemical Corporation
BASF Corporation
Bayer CropScience
Bellspray Inc. dba R&D Sprayers
Chemorse
Dow AgroSciences
DuPont Crop Protection
FMC Corporation
Growmark Inc.
Gylling Data Management Inc.
Integrated Lakes Management, Inc.
Heartland Technologies Inc.
Helena Chemical Company
Huntsman
Kumiai America
Makhteshim Agan of North America (MANA)
Monsanto Company
PBI/Gordon Corporation
Precision Laboratory
Syngenta Crop Protection
United Phosphorus, Inc.
Valent USA Corporation
Winfield Solutions LLC

# Attendees of the 2013 NCWSS Annual Meeting, Columbus, OH

Julie Abendroth
DuPont Pioneer
7300 NW 62nd Avenue, PO Box 1004
Johnston IA 50131
julie.abendroth@pioneer.com

Mary Joy Abit
Monsanto
3911 Maricopa Dr Unit 102
Ames IA 50014
joy.abit@monsanto.com

Bruce Ackley
Ohio State University
1683 King Ave
Columbus OH 43212
ackley.19@osu.edu

Jayla Allen
Bayer CropScience
1077 S. Lafayette Ave.
Marshall MO 65340
jayla.allen@bayer.com

Sara M Allen
Monsanto Company
13869 E Saddle Club Rd
Bonnie IL 62816
sara.m.allen@monsanto.com

Jill Alms
South Dakota State University
235 Ag Hall Box 2207A
Brookings SD 57007
jill.alms@sdstate.edu

Jared Alsdorf
ABG Ag Services
7275 N US 421
Sheridan IN 46069
jalsdorf@abgagservices.com

Joseph Argentine
AMVAC Chemical Corp
7 Lavenham Court
Tabernacle NJ 8088
joea@amvac-chemical.com

Joe Armstrong
Dow AgroSciences
4416 Belle Ave
Davenport IA 52807
jqarmstrong@dow.com

Chad Asmus
BASF Corporation
2301 Bristol Ln
Newton KS 67114
chad.asmus@basf.com

Collin Auwarter
North Dakota State University
P.O. Box 6050 Dept 7670
Fargo ND 58108
collin.auwarter@ndsu.edu

Ralph Bagwell
Bayer CropScience
50 Alfred Nobel Str. 50
Monheim 40789
ralph.bagwell@bayer.com

Rebecca Bailey
University of Wisconsin-Madison
1575 Linden Drive
Madison WI 53706
rredline@wisc.edu

Lucas Baldridge
University of Nebraska-Lincoln
279 PLSH
Lincoln NE 68583
luke.baldridge@unl.edu

Kelly Barnett
DuPont Crop Protection
49 Grassy Dr.
New Whiteland IN 46184
Kelly.a.barnett@dupont.com

Michael Barrett
University of Kentucky
105 Plant Science Bldg
Lexington KY 40546
mbarrett@uky.edu

Arthur Bass
Chemorse Ltd
1207 Second Ave
Kingstree SC 29556
arthurb@chemorse.com

Roger Becker
University of Minnesota
411 Borlaug / 1991 Upper Buford Circle
St Paul MN 55108
becke003@umn.edu

Lisa Behnken
Univ of Minn Extn Serv
863 30th Ave SE
Rochester MN 55901
lbehnken@umn.edu

Robert C Bellm
University of Illinois Extension
R.R. 2, Box 36A
Brownstown IL 62418
rcbellm@illinois.edu

Susan Bellman
Great Lakes Ag-Research Services, Inc.
N 6084 Johnson Rd
Delevan WI 53115
sbellman@greatlakesag.com

David Bennett
Bennett Ag Research Corp
1109 Ivy Ave
Richland IA 52585
barc_laurie@iowatelecom.net

Zachery Beres
The Ohio State University
1820 Lafayette Place Apt A2
Columbus OH 43212
beres.36@osu.edu

Scratch Bernard
Wilbur-Ellis Company
15 Dellwood
Canyon TX 79015
sbernard@wilburellis.com

Mark Bernards
Western Illinois University
Knoblauch Hall 227
Macomb IL 61455
ML-Bernards@wiu.edu

Sridevi Betha
Kansas State University
Kansas State University
Manhattan KS 66506
sridevi1@ksu.edu

Jim Bloomberg
Bayer CropScience
2 TW Alexander Dr
Res Tria Park NC 27709
jim.bloomberg@bayer.com

Joseph Bolte
University of Missouri
553 Chris dr.
Columbia MO 65203
jdbdhd@mail.missouri.edu

Elizabeth Bosak
University of Wisconsin-Madison
1575 Linden Dr
Madison WI 53706
ebosak@wisc.edu

Steven Bowe
BASF Corporation
PO Box 13528
Res Tria Park NC 27709
steven.bowe@basf.com

# Attendees of the 2013 NCWSS Annual Meeting, Columbus, OH

Luke Bozeman
BASF
26 Davis Dr
RTP NC 27709
luke.l.bozeman@basf.com

Kevin W Bradley
University of Missouri
201 Waters Hall
Columbia MO 65211
bradleyke@missouri.edu

Fritz Breitenbach
Univ of Minn Extension
863 30th Ave SE
Rochester MN 55901
breit004@umn.edu

Josh Brosz
Exacto, Inc.
2655 Fieldstone Drive
Victoria MN 55386
jbrosz@exactoinc.com

Dain Bruns
Syngenta Crop Protection
24435 Holycross Epps Rd
Marysville OH 43040
dain.bruns@syngenta.com

Meaghan Bryan
Iowa State University
1019 Agronomy Hall
Ames IA 50011
mjbryan@iastate.edu

John Buol
University of Wisconsin Madison
1575 Linden Drive
Madison WI 53715
jtbuol@wisc.edu

Tara Burke
University of Kentucky
267 Zandale Drive
Lexington KY 40503
Tara.Leigh.Burke@gmail.com

Thomas Butts
University of Wisconsin-Madison
1575 Linden Drive
Madison WI 53706
tbutts@wisc.edu

Holly Byker
University of Guelph
120 Main Street East
Ridgetown ON N0P2C0
hbyker@uoguelph.ca

Kellen Calinger
Ohio State University
318 West 12th Avenue
Columbus OH 43210
kcalinger@gmail.com

Tate Castillo
Bayer CropScience
112 Parkview St
Alma KS 66401
tate.castillo@bayer.com

Parminder Chahal
279 Plant Science,
University of Nebraska-Lincoln
Lincoln NE 68583
parminder.chahal@huskers.unl.edu

Leo D Charvat
BASF Corporation
6211 Saddle Creek Trail
Lincoln NE 68523
leo.charvat@basf.com

Laura Chatham
University of Illinois
320 ERML, 1201 W. Gregory Dr.
Urbana IL 61801
chatham1@illinois.edu

Dan Childs
Monsanto
659 Winslow Lane
West Lafayette IN 47906
dan.childs@monsanto.com

Whitney Churchman
University of Kentucky
1405 Veterans Drive Office #410
Lexington KY 40546
whitney.churchman@uky.edu

Carl Coburn
University of Wyoming
1503 East Baker Street
Laramie WY 80272
ccoburn2@uwyo.edu

Rick Cole
Monsanto Company E3NA
800 N Lindbergh Blvd
St Louis MO 63167
rmcole@monsanto.com

Jed Colquhoun
University of Wisconsin
1575 Linden Drive
Madison WI 62418
colquhoun@wisc.edu

Bob Condon
Clariant Chemical Corporation
625 East Catawba Avenue
Mount Holly NC 28173
bob.condon@clariant.com

Paul D Cornett
Kentucky Transportation Cabinet
200 Mero St, 3rd Floor East
Frankfort KY 40622
davidp.cornett@ky.gov

Chris Corzatt
Western Illinois University
508 South Williams
Colchester IL 62326
cp-corzatt@wiu.edu

Deanne Corzatt
Western Illinois University
508 South Williams
Colchester IL 62326
da-corzatt@wiu.edu

Arlene Cotie
Bayer
1724 Chestnut Hill Road
Wake Forest NC 61455
arlene.cotie@bayer.com

Todd Cowan
University of Guelph/ Research Station
70257 Airport Line, R.R. # 1
Exeter ON N0M 1S4
tcowan@uoguelph.ca

Cody Creech
University of Nebraska-Lincoln
201 West Francis Apt#1
North Platte NE 69101
cody.creech@huskers.unl.edu

Kevin Crosby
Adjuvants Unlimited LLC
7975 Courtyard Plaza
Memphis TN 38119
kcrosby@adjuvantsunlimited.com

Scott E Cully
Syngenta Crop Protection
17256 New Dennison Rd
Marion IL 62959
scott.cully@syngenta.com

Randall S Currie
Kansas State University
4500 E Mary St
Garden City KS 67846
rscurrie@ksu.edu

# Attendees of the 2013 NCWSS Annual Meeting, Columbus, OH

Susan Curvey
Monsanto Company
800 North Lindbergh Blvd., E1SB,
St. Louis MO 63167
susan.e.curvey@monsnto.com

Gregory Dahl
Winfield Solutions LLC
2777 Prairie Drive
River Falls WI 54022
gkdahl@landolakes.com

Trevor Dale
Valent USA Corporation
15610 56th Ave. N.
Plymouth MN 55446
tdale@valent.com

Adam Davis
N-319 Turner Hall
1102 S Goodwin
Urbana IL 61801
asdavis1@illinois.edu

Heidi Davis
University of Missouri
1508 War Admiral Dr.
Columbia MO 65202
hrdhw2@mail.missouri.edu

Vince Davis
University of Wisconsin-Madison
1575 Linden Drive
Madison WI 53706
vmdavis@wisc.edu

Andre de Oliveira Rodrigues
University of Nebraska
402 W State Farm Road
North Platte NE 69101
andrerodriguesdeoliveira@hotmail.co

Fernanda de Souza Antonio
University of Nebraska
402 W State Farm RD
North Platte NE 69101
fdsantonio@yahoo.com

Michael DeFelice
Pioneer Hi-Bred Int
PO Box 1150
Johnston IA 50131
michael.defelice@pioneer.com

Randy Degreeff
Kansas State University
4360 West Pleasant Hill Rd
Salina KS 62401
rbdegreeff@yahoo.com

Ken Deibert
BASF Corporation
458111 Whispering Sands Trail
Perham MN 56573
kenneth.j.deibert@basf.com

Katie Demers
Iowa State University
1126 Agronomy Hall
Ames IA 50014
kjdemers@iastate.edu

Darrell Deneke
South Dakota State University
Box 2207A Ag Hall
Brookings SD 57007
darrell.deneke@sdstate.edu

Pratap Devkota
Purdue University
915 W State Street
West Lafayette IN 47907
pdevkota@purdue.edu

Ryan DeWerff
University of Wisconsin-Madison
1575 Linden Dr.
Madison WI 53706
dewerff@wisc.edu

Johnathan Dierking
Monsanto
12 N Butler St Apt 507
Madison WI 53703
johnathan.dierking@monsanto.com

J Anita Dille
Kansas State University
3701 Throckmorton Hall
Manhattan KS 66506
dieleman@ksu.edu

Andrew Dillon
Kansas State University
1401 College Avenue
Manhattan KS 66502
ajdillon@ksu.edu

Scott Ditschun
University of Guelph
31 Vancouver Dr
Guelph ON N1E 2E7
sditschun@gmail.com

Anthony F Dobbels
The Ohio State University
223 Kottman Hall, 2021 Coffey Rd.
Columbus OH 62418
dobbels.1@osu.edu

Tammy Dobbels
United Suppliers Inc
7701 South Charleston Pike
South Charleston OH 45368
tammydobbels@unitedsuppliers.com

David L Doran
Bayer CropScience
2717 E 75 N
Lebanon IN 46052
dave.doran@bayer.com

Dave Downing
MANA
3120 Highwoods Blvd #100
Raleigh NC 27604
ddowning@manainc.com

Dirk C Drost
Syngenta Crop Protection
PO Box 18300
Greensboro NC 27419
dirk.drost@syngenta.com

Stewart Duncan
Kansas State
1007 Throckmorton Hall
Manhattan KS 61455
sduncan@ksu.edu

Cheryl L Dunne
Syngenta Crop Protection
7145 58th Ave
Vero Beach FL 32967
cheryl.dunne@syngenta.com

Emily Edler
Southern Illinois University
1205 Lincoln Drive
Carbondale IL 62901
eedler@siu.edu

Rick Edwards
Ohio State University
1680 Madison
Wooster OH 44691
edwards.1260@osu.edu

Andrew Esser
Kansas State University
3719 Throckmorton Hall
Manhattan KS 66506
aresser@ksu.edu

Anton Evans
University of Illinois
705 w Main apt 4
Urbana IL 61801
afevans2@illinois.edu

Attendees of the 2013 NCWSS Annual Meeting, Columbus, OH

Cody Evans
graduate student
1209 east florida avenue apt. 21 A
urbana IL 61801
cevans82@illinois.edu

Matt Faletti
Syngenta
14031 Trestle Rd
Highland IL 62249
Matt.Faletti@SYNGENTA.COM

Paul Feng
Monsanto Company
800 N. Lindbergh Blvd. 02G
St. Louis MO 63167
paul.feng@monsanto.com

Dave Ferguson
Huntsman
8600 Gosling Rd
The Woodlands TX 77381
dave_ferguson@huntsman.com

Walter H Fick
Kansas State University
Agronomy Dept. TH
Manhattan KS 66506
whfick@ksu.edu

Douglas Findley
Monsanto Company
4006 Old Leland Road
Leland MS 38756
douglas.a.findley@monsanto.com

Helen Flanigan
DuPont
1477 S Franklin Rd
Greenwood IN 46143
helen.a.flanigan@dupont.com

Darlene Florence
Emery Oleochemicals
4900 Este Avenue
Cincinnati OH 45232
darlene.florence@emeryoleo.com

Scott Flynn
DOW AGROSCIENCES
4407 NE Trilein Dr
Ankeny IA 50021
flynn@dow.com

Laura Ford
University of Guelph – Ridgetown
120 Main Street
Ridgetown ON N0P 2C0
fordlaura1@gmail.com

Robert Ford
Department of Horticulture
2021 Coffey Road
Columbus OH 43210
ford.413@osu.edu

Lucas Franca
Southern Illinois University
1205 Lincoln Drive
Carbondale IL 62901
lxfranca@siu.edu

Damian Franzenburg
Iowa State Univesity
2104 Agronomy Hall
Ames IA 50011
dfranzen@iastate.edu

John Frihauf
BASF Corporation
1008 Linden Crest Road
Raleigh NC 27603
john.frihauf@basf.com

Bruce A Fulling
Heartland Technologies Inc
12491 East 136th St
Fishers IN 46038
bfulling@heartlandinc.com

Karla Gage
River to River CWMA
8588 Route 148
Marion IL 62959
rtrcwma@gmail.com

Eric Gahler
Sunrise Cooperative
P O Box 870
Fremont OH 43420
lauranold@sunriseco-op.com

Zahoor Ganie
University of Nebraska-Lincoln
279 Plant Science Hall, East Campus
Lincoln NE 68583
zahoorganie11@huskers.unl.edu

Jesaelen Gizotti de Moraes
University of Nebraska
402 W State Farm RD
North Platte NE 69101
jgdmoraes1@hotmail.com

Les Glasgow
Syngenta Crop Protection
410 South Swing Rd.
Greensboro NC 62418
les.glasgow@syngenta.com

Chris Goblirsch
Riverton Research Inc
14619 15th Avenue Nt
Glyndon MN 56547
Chris_gob@loretel.net

AMAR GODAR
KANSAS STATE UNIVERSITY
2051 Kerr Drive R10
MANHATTAN KS 66502
godarws@live.com

David Goerig
Davey Resource Group
295 South Water Street
Kent OH 0
david.goerig@davey.com

Amanda Goffnett
Michigan State University
111 Rampart Way apt 301
East Lansing MI 48823
goffnet3@msu.edu

Michael Goley
Monsanto Company
GG3306-E, 700 Chesterfield Pkwy West
Chesterfield MO 61455
michael.e.goley@monsanto.com

Jeffrey Golus
University of Nebraska
402 West State Farm Road
North Platte NE 69101
jgolus1@unl.edu

Jared Goplen
University of Minnesota
1410 Carling Drive #10-106
Saint Paul MN 55108
gople007@umn.edu

Leah Granke
Dow AgroSciences
4963 Hilliard Green Dr.
Hilliard OH 43026
llgranke@dow.com

Greg Grant
Croda Inc
8124 Strecker Ln
Plano TX 75025
greg.grant@croda.com

Cody Gray
United Phosphorus, Inc.
11417 Cranston Drive
Peyton CO 80831
cody.gray@uniphos.com

Attendees of the 2013 NCWSS Annual Meeting, Columbus, OH

J D Green
University of Kentucky
413 Plant Sci Bldg
Lexington KY 40546
jdgreen@uky.edu

Jiaqi Guo
University of Illinois
320 ERML, 1201 W. Gregory Dr.
Urbana IL 61801
jguo13@illinois.edu

Aaron Hager
University of Illinois
1102 S Goodwin N-321 Turner Hall
Urbana IL 61801
hager@illinois.edu

Nick Harre
Southern Illinois University
1205 Lincoln Drive MC 4415
Carbondale IL 62901
nharre@siu.edu

Chandra Hawley
University of Nebraska
402 W State Farm RD
North Platte NE 69101
chandra.hawley@unl.edu

Joey Heneghan
Purdue University
915 W. State Street
West Lafayette IN 47907
jhenegh@purdue.edu

Erin C Hill
Michigan State University
A285 Plant & Soil Sci Bldg
E Lansing MI 48824
hiller12@msu.edu

Jerry Hora
Bayer CropScience
10786 90th Street
Maquoketa IA 52060
jerry.hora@bayer.com

Kirk Howatt
North Dakota State Univ
PO Box 6050 Dept 7670
Fargo ND 61455
kirk.howatt@ndsu.edu

Doug Hurak
The Scotts Company
14111 Scottslawn Rd
Marysville OH 43041
doug.hurak@scotts.com

Griff Griffith
Monsanto Company
700 Cheserfield Parkway N
Chesterfield MO 63017
griff.griffith@monsanto.com

Anders Gurda
UW Madison
923 Emerald St.
Madison WI 53715
andersbonders@gmail.com

Al Hamill
Hamill Enterprises
2643 County Rd 20, RR#1
Harrow ON N0R1G0
alhamill70@gmail.com

Kent Harrison
Ohio State University
2021 Coffey Road
Columbus OH 43210
harrison.9@osu.edu

Thomas A Hayden
BASF Plant Science
4033 Kensington Pl
Owensboro KY 42301
thomas.a.hayden@hotmail.com

Shane Hennigh
BASF Corporation
2435 Birch Street
Granger IA 50109
shane.hennigh@basf.com

David Hillger
Dow AgroSciences
6162 Grove Walk Court
Noblesville IN 62418
dehillger@dow.com

Michael Horak
Monsanto Company
800 N. Lindbergh Blvd
St. Louis MO 63141
michael.j.horak@monsanto.com

Jared Hoyle
Kansas State University
2021 Throckmorton
Manhattan KS 66506
jahoyle@ksu.edu

Joe Ikley
Purdue University
915 W State Street
West Lafayette IN 47907
jikley@purdue.edu

Jeffrey L Gunsolus
University of Minnesota
1991 Upper Buford Circle, 411 Borlaug
St Paul MN 55108
gunso001@umn.edu

Corey Guza
Winfield Solutions LLC
4729 Darbee Rd
Fairgrove MI 48733
cjguza@landolakes.com

Amanda Harden
Michigan State University
A451 Plant and Soil Sciences Bldg
East Lansing MI 48824
hardenam@msu.edu

Harlene Hatterman-Valenti
North Dakota State Univ
PO Box 6050 Dept 7670
Fargo ND 58108
h.hatterman.valenti@ndsu.edu

Brent Heaton
Western Illinois University
18310 North 350th Road
Industry IL 61440
bs-heaton@wiu.edu

Ryan Henry
University of Nebraska-Lincoln
402 W State Farm Road
North Platte NE 69101
rhenry5@unl.edu

John R Hinz
Bayer CropScience
54311 - 115th St
Story City IA 50248
john.hinz@bayer.com

Stott Howard
Syngenta Crop Protection
416 Foster Dr
Des Moines IA 50312
stott.howard@syngenta.com

Janel Huffman
University of Illinois
320 ERML, 1201 W. Gregory Dr.
Urbana IL 61801
jlhuffm2@illinois.edu

Amit Jhala
University of Nebraska-Lincoln
Plant Science Hall, East Campus
Lincoln NE 68583
amit.jhala@unl.edu

Attendees of the 2013 NCWSS Annual Meeting, Columbus, OH

David H Johnson
Pioneer Hi-Bred Int'l
7250 NW 62nd Ave
Johnston IA 50131
david.h.johnson@pioneer.com

Mithila Jugulam
Kansas State University
2004 Throckmorton Hall
Manhattan KS 66502
mithila@ksu.edu

Simranpreet Kaur
University of Nebraska- lincoln
279 Plant Science Hall, East Campus
Lincoln NE 68583
simranpreet.kaur@huskers.unl.edu

James J Kells
Michigan State University
468 Plant & Soil Sci Bldg
E Lansing MI 48824
kells@msu.edu

Stevan Knezevic
University of Nebraska
1009 Sherman
Wayne NE 68787
sknezevic2@unl.edu

Daniel Kohlhase
Iowa State University

Ames IA 50014
kohlhase@iastate.edu

Fritz Koppatschek
ABG AG Services
7275 N US 421
Sheridan IN 46069
fkoppatschek@abgagservices.com

Trevor Kraus
BASF Corporation
9188 East O Ave
Kalamazoo MI 49048
trevor.kraus@basf.com

Brian Kuehl
West Central Inc
284 Chestnut Dr
Horace ND 61455
bkuehl@westcentralinc.com

Rachel Lafferty
Croda Inc
1824 N Union St
Wilmington DE 19806
rachel.lafferty@croda.com

Jim Johnson
Syngenta
11684 Fenner Rd
Perry MI 48872
jim.johnson@syngenta.com

Chris Kamienski
Monsanto Company
708 Westgate Rd
Washington IL 61571
christopher.d.kamienski@monsanto.co

Angela Kazmierczak
North Dakota State University
PO Box 6050, Dept 7670
Fargo ND 58105
angela.kazmierczak@ndsu.edu

Andrew Kendig
Monsanto
700 Chesterfield Parkway
Chesterfield MO 63017
john.a.kendig@monsanto.com

Andrew Kniss
University of Wyoming
Dep. 3354, 1000 E University Ave
Laramie WY 82071
akniss@uwyo.edu

Jonathon R Kohrt
Micigan State
East Lansing MI 48824
kohrtjon@msu.edu

Mary Kornegay
Gibbs & Soell Business Communications
8521 Six Forks Road, Suite 300
Raleigh NC 62418
mkornegay@gibbs-soell.com

Ron Krausz
Southern Illinois University
2036 Charles Lane
Belleville IL 62221
rkrausz@siu.edu

Alan Kurtz
Bayer CropScience
11466 Bluebonnet Court
Plymouth IN 46563
alan.kurtz@bayer.com

David J Lamore
Bayer CropScience
107 Sunrise Ln
Bryan OH 43506
david.lamore@bayer.com

Tyler Johnson
Ohio State University
242 W 8th Ave. Apt. C
Columbus OH 43201
johnson.4625@osu.edu

Brady Kappler
BASF Corporation
20201 North Stable Dr
Eagle NE 68347
brady.kappler@basf.com

Ray Kelley
Greenleaf Technologies
P. O. Box 1767
Covington LA 70434
rk@turbodrop.com

Troy D Klingaman
BASF Corporation
1403 N Brookhaven
Mahomet IL 61853
troy.klingaman@basf.com

Masanori Kobayashi
K-I Chemical USA
11 Martine Avenue Suites 1460
White Plains NY 10606
masanori.kobayashi@kichem-usa.com

Samantha Konkle
Ohio State University
2021 Coffey Road
Columbus OH 43210
konkle.4@buckeyemail.osu.edu

Chris Kramer
University of Guelph
Ridgetown Campus
Ridgetown ON N0P-2C0
ckramer@uoguelph.ca

Greg R Kruger
University of Nebraska
402 W State Farm Rd
North Platte NE 69101
gkruger2@unl.edu

John Laborde
University of Nebraska - Lincoln
5610 Huntington Ave.
Lincoln NE 28507
jlaborde@huskers.unl.edu

Clayton Larue
Monsanto Company
700 Chesterfield PKWY W
Chesterfield MO 63017
clayton.t.larue@monsanto.com

Attendees of the 2013 NCWSS Annual Meeting, Columbus, OH

Ryan Lee
Dow AgroSciences
9330 Zionsville Rd
Indianapolis IN 46268
RMLee@dow.com

Dustin Lewis
BASF Corporation
320 County Road 1100 North
Seymour IL 61875
dustin.f.lewis@basf.com

John Lindquist
University of Nebraska
279 Plant Science Hall
Lincoln NE 68583
jlindquist1@unl.edu

Alex Long
University of Missouri
110 Waters Hall
Columbia MO 65211
longale@missouri.edu

James Lux
Iowa State University
2517 Agronomy Hall
Ames IA 50011
jlux@iastate.edu

Bruce Maddy
Dow AgroSciences
102 Queensbury Ct
Noblesville IN 46062
bemaddy@dow.com

Mayank Malik
Monsanto
7551 Crystal Ct
Lincoln NE 68506
mayank.s.malik@monsanto.com

Peter B Matey
Huntsman
10003 Woodloch Forest Drive
The Woodlands TX 77380
peter_b_matey@huntsman.com

Chris Mayo
Monsanto
625 S. Plum Creek Circle
Gardner KS 61455
christopher.m.mayo@monsanto.com

Patrick McMullan
United Suppliers, Inc.
224 South Bell Ave.
Ames IA 50010
PatrickMcMullan@unitedsuppliers.com

Travis Legleiter
Purdue University
915 W State Street
West Lafayette IN 47907
tlegleit@purdue.edu

Zhenyi Li
University of Guelph
50 stone road E
guelph ON N1G 2W1
zhenyi@uoguelph.ca

Ryan Lins
Syngenta Crop Protection
63193 280th Ave.
Byron MN 55920
ryan.lins@syngenta.com

Jamie Long
Southern Illinois University
1205 Lincoln Drive
Carbondale IL 62901
jamie.long@siu.edu

Rong Ma
University of Illinois
105 Crystal Lake Dr.
Urbana IL 61801
rongma2@illinois.edu

Lillian Magidow
Winfield Solutions
2777 Prairie Drive
River Falls WI 54022
lcmagidow@landolakes.com

James R Martin
University of Kentucky
PO Box 469 Agronomy
Princeton KY 62418
jamartin@uky.edu

KAZUHO MATSUO
Kumiai America (K-I Chemical)
11 MARTINE AVE. Suite 1460
White Plains NY 10606
kmatsuo@kichem-usa.com

Melinda McCann
Monsanto
800 North Lindbergh Blvd. BB5B
St. Louis MO 63167
melinda.c.mccann@monsanto.com

Michael Meyer
DuPont Crop Protection
704 7th Ave. SE
Altoona IA 50009
michael-devin.meyer@dupont.com

Robert Leskovsek
Agricultural Institute of Slovenia
Hacquetova ulica 17
Ljubljana Slovenia SI-1000
Robert.leskovsek@kis.si

Gregory Lindner
CRODA Inc
315 Cherry Ln
New Castle DE 19720
greg.lindner@croda.com

Seth Logan
Southern Illinois University
7163 State Rt 154
Tamaroa IL 62888
seth.t.logan@monsanto.com

Mark Loux
Ohio State University
2021 Coffey Rd
Columbus OH 43221
loux.1@osu.edu

Alison MacInnes
Monsanto Company
17584 Garden Ridge Cir
Wildwood MO 63038
alison.macinnes@monsanto.com

Kris Mahoney
University of Guelph, Ridgetown
120 Main St. East
Ridgetown ON 0
kmahoney@uoguelph.ca

Bob Masters
Dow AgroSciences
9335 Windrift Way
Zionsville IN 46077
ramasters@dow.com

Doug Maxwell
University of Illinois
1102 S Goodwin Ave., N-333 Turner
Urbana IL 61801
dmaxwell@illinois.edu

Kevin McGregor
Iowa State University
1408 NE Williamsburg Drive
Ankeny IA 50021
kevin1@iastate.edu

Jan Michaez
Michigan State
1066 Bogue St.
East Lansing MI 48824
michae42@msu.edu

Attendees of the 2013 NCWSS Annual Meeting, Columbus, OH

Brett Miller
Syngenta
11055 Wayzata Blvd
Minnetonka MN 55305
brett.miller@syngenta.com

David Morgenstern
Monsanto Co
800 N. Lindbergh Blvd
St. Louis MO 63167
david.a.morgenstern@monsanto.com

Dario Narvaez
MANA
2454 Indian Tree Circle
Wildwood MO 63038
dnarvaez@manainc.com

Kindsey Niehues
Kansas State University
1551 88th Rd.
Goff KS 66428
myersk@ksu.edu

Joe Omielan
University of Kentucky
Plant & Soil Sci, 1405 Veterans Dr.
Lexington KY 40546
joe.omielan@uky.edu

Emilio Oyarzabal
Monsanto
800 N Lindbergh Blvd
St Louis MO 63304
emilio.s.oyarzabal@monsanto.com

Carey Page
University of Missouri
110 Waters Hall
Columbia MO 65211
pagecf@missouri.edu

Donald Penner
Michigan State University
1066 Bogue St
E Lansing MI 48824
pennerd@msu.edu

Mark Peterson
Dow AgroSciences
5632 Acre Lane
West Lafayette IN 61455
mapeterson@dow.com

John Pike
University of Illinois
354 St. Hwy. 145 North
Simpson IL 62985
jpike@illinois.edu

Keith Miller
MANA
120 Oak Land Drive
Troy IL 62294
kmiller@manainc.com

Carroll Moseley
Syngenta
410 Swing Road
Greensboro NC 27265
carroll.moseley@syngenta.com

Kelly Nelson
Univeristy of Missouri
PO Box 126
Novelty MO 63460
nelsonke@missouri.edu

Douglas W Nord
Diamond Ag Research Inc
855 K19 Hwy South
Larned KS 67550
dwnord@gbta.net

Eric J Ott
Valent USA Corporation
1898 W US 40
Greenfield IN 46140
eric.ott@valent.com

Kevin O'Dell
ONLA
3512 St. Martins Pl.
Cincinnati OH 45211
kmo@kendrickodell.com

Jason Parrish
Ohio State University
2021 Coffey Rd, 202 Kottman Hall
Columbus OH 62418
parrish.174@osu.edu

Brent B Petersen
Cropwise Research LLC
852 1st Street N
Sartell MN 56377
bp.cropwise@gmail.com

Brent Philbrook
Bayer CropScience
PO Box 219
Seymour IL 61875
brent.philbrook@bayer.com

Abelino Pitty
Zamorano
Escuela Agrícola Panamericana
Zamorano FM
apitty@zamorano.edu

Mohsen Mohseni Moghadam
Ohio State University
907 Carriage Lane
Wooster OH 44691
mmmbio1685@yahoo.com

Adrian J Moses
Syngenta Crop Protection
PO Box 27
Gilbert IA 50105
adrian.moses@syngenta.com

scott nelson
pioneer
9131 north park
johnston IA 50131
scott.m.nelson@pioneer.com

Brian Olson
Monsanto
905 South Washington
Colby KS 67701
powercat79@gmail.com

M D K Owen
Iowa State University
3218 Agronomy Hall
Ames IA 50011
mdowen@iastate.edu

Brent Pacha
Bennett Ag Research Corp
1109 Ivy Ave
Richland IA 52585
barcbrent@iowatelecom.net

John Pawlak
Valent USA Corporation
7340 Sandpiper Ln
Lansing MI 48917
john.pawlak@valent.com

Dallas E Peterson
Kansas State University
113 Harvard Place
Manhattan KS 66503
dpeterso@ksu.edu

Ray Pigati
WinField
1080 County Rd. F W
Shoreview MN 55126
rlpigati@landolakes.com

Peter Porpiglia
Amvac Chemical Corporation
4695 MacArthur Court Suite 1200
Newport Beach CA 92660
zedak@amvac-chemical.com

# Attendees of the 2013 NCWSS Annual Meeting, Columbus, OH

Don Porter
Syngenta
PO Box 18300
Greensboro NC 27419
don.porter@syngenta.com

Gary E Powell
Michigan State University
A285 Plant & Soil Sciences
E Lansing MI 48824
powellg@msu.edu

Analiza Henedina Ramirez
Monsanto Company
1 Cotton Row
Scott MS 38772
haydee.ramirez@monsanto.com

Zane Raudenbush
Kansas State University
2021 Throckmorton Plant Science
Manhatton KS 66506
zane12@ksu.edu

Bryan Reeb
Ohio State University
223 Kottman Hall, 2021 Coffey Rd.
Columbus OH 43210
reeb.22@osu.edu

David L Regehr
retired
12051 Homestead Rd
Riley KS 66531
dregehr@ksu.edu

James D Reiss
Precision Labs
1429 S Shields Dr
Waukegan IL 60085
diana.freeman@precisionlab.com

Lee Richards
CRODA
315 Cherry Ln
New Castle DE 19720
lee.richards@croda.com

Spencer Riley
University of Missouri
110 Waters Hall
Columbia MO 61455
sar5k2@mail.missouri.edu

Maria Angelica Rojas
Student
120 Main St East
Ridgetown ON N0P 2C0
rojasm@nsac.ca

Rich Porter
Amvac Chemical Corp
4695 MacArthur Ct
Newport Beach CA 92660
richardp@amvac-chemical.com

Richard T Proost
University of Wisconsin
445 Henry Hall
Madison WI 53706
rproost@wisc.edu

Neha Rana
Monsanto Company
700 Chesterfield Pkwy West
Chesterfield MO 63017
neha.rana@monsanto.com

Ross Recker
University of Wisconsin-Madison
1575 Linden Dr.
Madison WI 53706
rrecker@wisc.edu

Kirk Reese
DuPont Pioneer
59 Greif Parkway Suite 200
Delaware OH 43015
kirk.reese@pioneer.com

Emilie Regnier
Ohio State University Hort & Crop Sci
2021 Coffey Rd
Columbus OH 43210
regnier.1@osu.edu

Karen Renner
Michigan State University
A285 Plant & Soil Sci Bldg
E Lansing MI 62418
renner@msu.edu

Dean E Riechers
Univ of Illinois Crop Science
1102 S Goodwin AW-101 Turner Hall
Urbana IL 61801
riechers@illinois.edu

Darren Robinson
University of Guelph
120 Main Street East
Ridgetown ON N0P 2C0
darrenr@uoguelph.ca

Jonathan Rollins
Researcher
12491 E136th street
Fishers IN 46038
Jon@heartlandinc.com

David Powell
Michigan State University
Department of Crop and Soil Sciences
East Lansing MI 48824
powel137@msu.edu

Joe Rains
Plant Research Services
6084 Shelby 240
Bethel MO 63434
ljrains@marktwain.net

Duane P Rathmann
BASF Corporation
604 9th St NE
Waseca MN 56093
duane.rathmann@basf.com

Ryan Rector
Monsanto Company
369 Huntleigh Manor Dr.
St. Charles MO 63303
ryan.j.rector@monsanto.com

Dawn Refsell
Valent USA Corporation
220 NE Brown Rd
Lathrop MO 64465
dawn.refsell@valent.com

Theresa Reinhardt
Southern Illinois University
1205 Lincoln Drive MC 4415
Carbondale IL 62901
ttgirl@siu.edu

Mark Renz
University of Wisconsin
1575 Linden Dr
Madison WI 53706
mrenz@wisc.edu

Chance Riggins
University of Illinois
1201 W Gergory Dr
Urbana IL 61801
criggins@life.illinois.edu

Steve Roehl
West Central Inc
816 Olena Avenue SE
Willmar MN 56201
sroehl@westcentralinc.com

Kristin Rosenbaum
Dow AgroSciences
7047 N Grand Lake Drive
Lincoln NE 68521
kkrosenbaum@dow.com

# Attendees of the 2013 NCWSS Annual Meeting, Columbus, OH

Mark Rosenberg
SDSU Extension
13 2nd Ave. SE
Aberdeen SD 57401
mark.rosenberg@sdstate.edu

Ahmed Sadeque
University of Illinois
1201 W. Gregory Dr.
Urbana IL 61801
ahmed.sadeque@gmail.com

Leah Sandler
University of Missouri
PO Box 126
Novelty MO 63460
lnsp59@mizzou.edu

Irvin Schleufer
University of Nebraska
Box 66
Clay Center NE 68933
ischleufer1@unl.edu

Bert Schou
ACRES Research
PO Box 249
Cedar Falls IA 50613
bertschou@aol.com

Tammy Schweiner
Huntsman
25503 Dappled Filly Drive
Tomball TX 77375
tammy-schweiner@huntsman.com

Frank Sexton
Exacto, Inc.
200 Old Factory Rd
Sharon WI 53585
fsexton@exactoinc.com

Taiki Shiobara
ISK Bioscience
211 S Platte Clay Way Suite B
Kearney MO 64060
shiobarat@iskbc.com

Peter H Sikkema
University of Guelph
120 Main Street East
Ridgetown ON 61455
psikkema@uoguelph.ca

Alec Simpson
Croda Inc.
315 Cherry Lane
New Castle DE 19720
alec.simpson@croda.com

Jared Roskamp
BASF
986 E Co Rd 350 N
Sutter IL 62373
jared.roskamp@basf.com

Joe Sandbrink
Monsanto Company
1087 Nooning Tree Dr
St Louis MO 63017
joseph.j.sandbrink@monsanto.com

Debalin Sarangi
University of Nebraska- Lincoln
279 Plant Science Hall, East Campus
Lincoln NE 68583
debalin.sarangi@huskers.unl.edu

Rick Schmenk
Great Lakes Crop Tech, LLC
13115 Maple Rd
Milan MI 48160
weedkllr@aol.com

John Schultz
University of Missouri
108 Waters Hall
Columbia MO 65211
jsqf4@mail.missouri.edu

Jon E Scott
University of Nebraska
616 Michener St
Wakefield NE 68784
jescott71@yahoo.com

Dale Shaner
Retired
2815 Stonehaven Drive
Fort Collins CO 62418
dlshaner37@gmail.com

Matt Shipp
Oxiteno
9801 Bay Area Blvd.
PASADENA TX 77316
matt.shipp@rocketmail.com

George Simkins
Bayer CropScience
6928 Pleasant View Dr.
St. Paul MN 55112
george.simkins@bayer.com

David Simpson
Dow AgroSciences
9747 Greenthread Dr
Zionsville IN 46077
dmsimpson@dow.com

David C Ruen
Dow AgroSciences
26047 Gladiola Ln
Lanesboro MN 55949
dcruen@dow.com

Lowell Sandell
University of Nebraska
174 Keim Hall
Lincoln NE 68583
lsandell2@unl.edu

Jess Schafer
Purdue University
915 W State Street
W Lafayette IN 47907
schafer3@purdue.edu

Jared Schmidt
University of Nebraska - Lincoln
279 Plant Science Hall
Lincoln NE 68583
jaredschmidt@huskers.unl.edu

Lauren Schwartz
Southern Illinois University
1205 Lincoln Drive
Carbondale IL 62901
lschwartz@siu.edu

Beth Sears
United Phosphorus, Inc
100 Wilson Drive
Lincoln NE 19352
beth.sears@uniphos.com

Tye Shauck
University of Missouri
110 Waters Hall
Columbus MO 65211
tcs2m5@missouri.edu

Douglas E Shoup
Kansas State University
308 W 14th
Chanute KS 66720
dshoup@ksu.edu

Bill Simmons
University of Illinois
1301 W Gregory Dr
Urbana IL 61801
fsimmons@illinois.edu

Joshua Skelton
University of Illinois
2410 Fields South Drive Apt. 206
Champaign IL 61822
skelton2@illinois.edu

# Attendees of the 2013 NCWSS Annual Meeting, Columbus, OH

Charles Slack
University of Kentucky
415 Plant Science
Lexington KY 40546
cslack@uky.edu

Reid Smeda
University of Missouri
110 Waters Hall
Columbia MO 65211
smedar@missouri.edu

Clyde Smith
United Phosphorus Inc
2228 Bridge Creek
Marianna FL 32448
clyde.smith@uniphos.com

Daniel Smith
University of Wiscosin-Madison
1575 Linden Drive
Madison WI 53706
dhsmith@wisc.edu

Randy Smith
Dow AgroSciences
14813 Bixby Dr.
Westfield IN 46074
rsmith4@dow.com

Allison Snow
Ohio State University, Dept of EEOB
318 W 12th Ave
Columbus OH 43210
snow.1@osu.edu

Nader Soltani
University of Guelph
120 Main St. East
Ridgetown ON N0P 2C0
soltanin@uoguelph.ca

Eric Spandl
Winfield Solutions LLC
1080 County Road F West
Shoreview MN 55126
epspandl@landolakes.com

Doug Spaunhorst
Purdue University
915 W. State Street
West Lafayette IN 47907
dspaunho@purdue.edu

Jess J Spotanski
Midwest Research Inc
910 Road 15
York NE 68467
jess@midwestresearchinc.com

Christy Sprague
Michigan State University
466 Plant & Soil Sci Bldg
E Lansing MI 48824
sprague1@msu.edu

Jeff Stachler
Willowood USA
16505 50 1/2 St. SE
Kindred ND 58051
jeffs@willowoodusa.com

Lizabeth Stahl
University of Minnesota
1527 Prairie Drive
Worthington MN 56187
stah0012@umn.edu

Phillip Stahlman
Kansas State University
1232 240th Avenue
Hays KS 67601
stahlman@ksu.edu

Strahinja Stepanovic
UNL
1342 B street
Lincoln NE 68502
strahinja87@gmail.com

Alan Stern
Huntsman
8600 Gosling Rd
The Woodlands TX 77354
alan-j-stern@huntsman.com

David Stevenson
Stewart Agric Research Serv
2024 Shelby 210
Clarence MO 63437
dsteve@marktwain.net

Rod Stevenson
Monsanto
10267 N 19 th street
Plainwell MI 49080
rod.stevenson@monsanto.com

Brad Stierwalt
University of Illinois
1102 S Goodwin Ave
Urbana IL 61801
saosterb@att.net

Mark A Storr
BASF Corporation
25336 Byron Circle
Nevada IA 62418
mark.storr@basf.com

Ryan Strash
200 Old Factory Rd
Sharon WI 53179
rstrash@exactoinc.com

Jeff Taylor
DuPont Pioneer
59 Greif Parkway West, Suite 200
Delaware OH 43015
jeff.taylor@pioneer.com

David Thomas
Syngenta Crop Protection
608 Kratz Road
Monticello IL 61856
dave.thomas@syngenta.com

Walter E Thomas
BASF Corporation
P.O. Box 13528, 26 Davis Drive
Durham NC 27709
walter.e.thomas@basf.com

Curtis R Thompson
Kansas State University
2014 Throckmorton Hall
Manhattan KS 61455
cthompso@ksu.edu

Drew Thompson
BASF Canada
320 Irish Line, RR#3
Cayuga ON N0A 1E0
drew.thompson@basf.com

Kevin Thorsness
Bayer CropScience
21 Prairiewood Dr
Fargo ND 58103
kevin.thorsness@bayer.com

Rodney Tocco
Winfield Solutions
1080 County Road F West
Shoreview MN 55126
rvtocco@landolakes.com

Dennis Tonks
ISK Biosciences
211 S Platte Clay Way, Suite B
Kearney MO 64060
tonksd@iskbc.com

Patrick Tranel
University of Illinois
1201 W Gregory Dr, 360 ERML
Urbana IL 61801
tranel@illinois.edu

# Attendees of the 2013 NCWSS Annual Meeting, Columbus, OH

Jeff Travers
Monsanto
800 N. Lindbergh Blvd.
St. Louis MO 63167
jeff.n.travers@monsanto.com

Tim Trower
Syngenta
E10249A Hoot Owl Valley Rd
Baraboo WI 53913
Tim.Trower@syngenta.com

Jared Unverzagt
BASF
1309 Cobblestone Way
Champaign IL 61822
jared.unverzagt@basf.com

Gordon Vail
Syngenta  Crop Protection
PO Box 18300
Greensboro NC 27419
gordon.vail@syngenta.com

Stepen A Valenti
Monsanto Company
5132 Rosecreek Pkwy
Fargo ND 58104
stephen.a.valenti@monsanto.com

Lacy Valentine
University of Nebraska - Lincoln
1002 N 8th Street
Nebraska City NE 68410
lacy.valentine@huskers.unl.edu

Annemarie Van Wely
University of Guelph
120 Main St. East
Ridgetown ON N0P 2C0
avanwely@uoguelph.ca

Vijayakrishna Varanasi
Kansas State University
3722 Throckmorton Plant Sciences
Manhattan KS 66506
varanasi@ksu.edu

RAMARAO VENKATESH
THE OHIO STATE UNIVERSITY
2021 COFFEY ROAD
COLUMBUS OH 43210
venkatesh.1@osu.edu

David Vos
South Dakota State University
235 Berg Ag Hall - SDSU
Brookings SD 57006
dave.vos@sdstate.edu

Mark Waddington
Bayer CropScience
3956 Cross Creek Trail
Owensboro KY 42303
mark.waddington@bayer.com

Aaron Waltz
Pioneer Hi-Bred Int'l
1039 S Milton-Shopiere
Janesville WI 53547
aaron.waltz@pioneer.com

Loyd M Wax
Univ. of Illinois / ARS (Retired)
13 River Valley Ranch Road
White Heath IL 61884
lmwax@illinois.edu

Mike Weber
Bayer CropScience
2208 North 9th St
Indianola IA 50125
michael.weber3@bayer.com

Stephanie Wedryk
Winfield Solutions, LLC
1080 County Road F West MS 5745
Shoreview MN 55126
slwedryk@landolakes.com

Gery Welker
BASF Corporation
2292 S 400 W
Winamac IN 46996
gery.welker@basf.com

Rodrigo Werle
University of Nebraska
279 Plant Science Hall
Lincoln NE 68583
rwerleagro@gmail.com

Natalie West
USDA-ARS
1102 South Goodwin
Urbana IL 61801
nmwest@illinois.edu

Phil Westra
Colorado State Univ
112 Weed Lab
Ft Collins CO 80523
cows@comcast.net

Tony White
Monsanto Company
161 Berry Bramble Court
Lake Saint Louis MO 62418
tony.d.white@monsanto.com

Matthew Wiggins
University of Tennessee
605 Airways Blvd.
Jackson TN 38301
mwiggin8@utk.edu

Gerald Wiley
Wiley Ag Research Services, LLC
50 S, 250 East
Columbus IN 47201
wileyag@comcast.net

Alexandra Williams
University of Kentucky
912 Cramer Ave
Lexington KY 40502
apwi222@uky.edu

John Willis
Monsanto Company
1621 Slaughters Lake Road
Hanson KY 42413
john.b.willis@monsanto.com

Greg Willoughby
Helena Chemical Co
10004 S. 100 East
Lafayette IN 61455
WilloughbyG@helenachemical.com

Devin Wirth
North Dakota State University
1360 Albrecht Blvd
Fargo ND 58105
devin.a.wirth@ndsu.edu

William Witt
University of Kentucky
411 Plant Science Bldg
Lexington KY 40546
wwitt@uky.edu

Robert Wolf
Wolf Consulting & Research LLC
2040 County Road 125 E
Mahomet IL 61853
bob@rewolfconsulting.com

Ryan Wolf
Winfield Solutions
4941 280th St
Sheldon IA 51201
rrwolf@landolakes.com

Mark Wrucke
Bayer CropScience
19561 Exceptional Trail
Farmington MN 55024
mark.wrucke@bayer.com

# Attendees of the 2013 NCWSS Annual Meeting, Columbus, OH

Chenxi Wu
University of Illinois
509 W Main St, Apt 10
Urbana IL 61801
cwu43@illinois.edu

Joseph Wuerffel
Southern Illinois University
304 E. Hester St.
Carbondale IL 62901
rwuerff@siu.edu

Bryan Young
Southern Illinois Univesity
Carbondale IL 62901
bgyoung@siu.edu

Deane Zahn
Syngenta Crop Protection LLC
317 330th Street
Stanton MN 55018
deane.zahn@syngenta.com

Joe Zawierucha
BASF Corporation
26 Davis Dr
Res Tria Park NC 27709
joseph.zawierucha@basf.com

Richard Zollinger
North Dakota State Univ
PO Box 6050 Dept 7670
Fargo ND 58108
r.zollinger@ndsu.edu

Attendees of the Invasive Plants Symposium Sponsored by MIPN

Karen Adair
The Nature Conservancy
3973 Callender Road
Rock Creek OH 44084
kadair@tnc.org

Dave Apsley
Ohio State University Extension
Jackson OH
apsley.1@osu.edu

Thomas Arbour
Division of Natural Areas & Preserves
6829 Alloway St. E.
Worthington OH 43085
hiramtom@gmail.com

Mary Arthur
University of Kentucky
TP Cooper Building
Lexington KY 40546
marthur@uky.edu

Alina Avanesyan
Department of Biological Sciences,
9623 Waterford Place apt 310
Loveland OH 45140
alina.avanesyan@gmail.com

Chuck Bebout
Columbus Zoo & Aquarium
Box 400
Powell OH 43065-0400
chuck.bebout@columbuszoo.org

Stephen Belcher
Columbus Zoo & Aquarium
Box 400
Powell OH 43065-0400
stephen.belcher@columbuszoo.org

Wes Bickford
USGS - Great Lakes Science Center
809 Hillcrest Dr
Ann Arbor MI 48103
wesbick@yahoo.com

Tom Borgman
Great Parks of Hamilton County
10245 Winton Road
Cincinnati OH 45231
tborgman@greatparks.org

Joel Bossley
Columbus Zoo & Aquarium
Box 400
Powell PA 43065-0400
joel.bossley@columbuszoo.org

Andy Bowden
The Wilds
14000 International Road
Cumberland OH 43732
cpeugh@thewilds.org

Richard Boyce
MIPN
7061 Grantham Way
Cincinnati OH 45230
richardboyce@fuse.net

Rick Boyce
Northern Kentucky University
7061 Grantham Way
Cincinnati OH 45230
richardboyce@fuse.net

Anita Brar
The Wilds
14000 International Road
Cumberland OH 43732
cpeugh@thewilds.org

Shana Byrd
The Wilds
14000 International Road
Cumberland OH 43732
cpeugh@thewilds.org

Margaret Carreiro
University of Louisville
2011 Eastview Ave.
Louisville KY 40205
m.carreiro@louisville.edu

Ron Carter
ODNR DOW
4310 E. 5th ave.
Columbus OH 43219
caleb.shields@dnr.state.oh.us

Don Cipollini
Wright State University
Fairborn OH
no@23e-mail.com

Kendra Cipollini
Wilmington College
1870 Quaker Way
Wilmington OH 45177
kendra_cipollini@wilmington.edu

Meredith Cobb
Five Rivers MetroParks
941 Manhattan Ave
Dayton OH 45406
mcobb@metroparks.org

Michelle Comer
Ohio Department of Natural Resources
2045 Morse Rd. Bldg C-3
Columbus OH 43229
Michelle.Comer@dnr.state.oh.us

Brian Courtney
The Wilds
14000 International Road
Cumberland OH 43732
cpeugh@thewilds.org

Theresa Culley
University of Cincinnati
7329 Lakota Springs Dr.
West Chester OH 45069
culley.5@osu.edu

samantha davis
wright state university
85 Westport Drive
Fairborn OH 45324
davis.598@wright.edu

Jennifer Dean
NY Natural Heritage Program
14 Moulds Ave
Rensselaer NY 12144
dean@nynhp.org

Guy Denny
Ohio Natural Areas and Preserves
6021 Mt. Gilead Road
Fredericktown OH 43019-9513
guydenny@centurylink.net

Nick Dios
Davey Resource Group
1500 N. Mantua
Kent OH 44240
nick.dios@davey.com

Amy Dirks
Lake Metroparks
11211 Spear Rd
Concord Twp OH 44077
adirks@lakemetroparks.com

Heidi Edwards
Ohio Department of Natural Resources
2045 Morse Rd. Bldg C-3
Columbus OH 43229
Michelle.Comer@dnr.state.oh.us

Jessica Ellison
The Wilds
14000 International Road
Cumberland OH 43732
cpeugh@thewilds.org

Attendees of the Invasive Plants Symposium Sponsored by MIPN

Jillian English
The Wilds
14000 International Road
Cumberland OH 43732
cpeugh@thewilds.org

Sara Ernst
Franklin Soil and Water Conseration
1328 Dublin Rd
Columbus OH 43215
semst@franklinsurcd.org

Roger Etzell
ohio
6703 5K Ave
Greenville OH 45331
rogeretzell@yahoo.com

Chris Evans
MIPN
2114 Market Road
Marion IL 62959
chris.evans@illinois.gov

Win Fox
The Wilds
14000 International Road
Cumberland OH 43732
cpeugh@thewilds.org

Kurt Gaertner
Cincinnati Nature Center
4949 Tealtown Road
Milford OH 45150
kgaertner@cincynature.org

Rick Gardner
Ohio Division of Natural Areas
307 N Union St
Delaware OH 43015
rick.gardner@dnr.state.oh.us

Donald Geiger
MEEC Univ Dayton
4435 E. Patterson Rd
Dayton OH 45430
dgeiger1@udayton.edu

Keith Gilland
Miami University
1519 Tabor Ave
Kettering OH 45420
kg548007@ohio.edu

Susan Gitlin
USEPA
609 Little St
Alexandria VA 22301
susan.mclaughlin@alumni.stanford.ed

Rachael Glover
The Wilds
14000 International Road
Cumberland OH 43732
cpeugh@thewilds.org

Nate Godby
Wilmington College
1870 Quaker Way
Wilmington OH 45177
ngodby@wilmington.edu

Spencer Goehl
Eco Logic LLC
3940 W Farmer Ave.
Bloomington IN 47403
spencer@ecologicindiana.com

Karen Goodell
The Ohio State University
732D Nobel Drive
Santa Cruz CA 95060
karengoodell66@gmail.com

Margie Goodin
the Conservationist
7277 W. Piqua-Clayton Rd.
Covington OH 45318
Terry.Lavy@gmail.com

David Gorchov
Miami University
700 East High St.
Oxford OH 45056
GorchoDL@muohio.edu

David Gorden
MIPN
1801 Senate Blvd
Indianapolis IN 46202-1263
degorden@sbcglobal.net

Jerry Greer
Ohio Certified Volunteer Naturalist
124 Melody Lane
Pataskala OH 43062
swihart.33@osu.edu

Anna Greis
USDA Forest Service
1720 Peachtree Rd. NW
Atlanta GA 30309
bbudlong@fs.fed.us

Katie Grzesiak
Northwest Michigan Invasive Species
1450 Cass Rd
Traverse City MI 49685
kgrzesiak@gtcd.org

Peter Guiden
Miami University
700 East High St.
Oxford OH 45056
GorchoDL@muohio.edu

Christine Hadley
Cincinnati Wild Flower Preservation
445 Ward Koebel Rd
Oregonia OH 45054
sbatcha1@earthlink.net

Mary Henry
Miami University
80 Autumn Dr
Oxford OH 45056
adenostoma@gmail.com

Nathan Herbert
TNC - Indiana
330 Intertech Parkway Ste. 110
Angola IN 46703
nherbert@tnc.org

Nora Hiland
Ohio Invasive Plants Council
799 EXECUTIVE BLVD
DELAWARE OH 430151188
nhiland@columbus.rr.com

Karl Hoessle
City of Columbus, Recreation and Parks
1533 Alum Industrial Drive West
Columbus OH 43219
JMBuckley@columbus.gov

Judy Holtvogt
OIPC Board
6815 Wonder Way
Tipp City OH 45371
jjhtipp@gmail.com

Brian Hoven
Miami University
700 East High St.
Oxford OH 45056
GorchoDL@muohio.edu

Katherine Howe
Midwest Invasive Purdue University
401 S Grant Street
West Lafayette IN 47907
howek@purdue.edu

Kathy Huffman
U.S. Fish and Wildlife Service
14000 W. State Route 2
Oak Harbor OH 43449
ron_huffman@fws.gov

# Attendees of the Invasive Plants Symposium Sponsored by MIPN

John Kaiser
ODNR-Division of Wildlife
4310 East Fifth Ave.
Columbus OH 43219
john.kaiser@dnr.state.oh.us

Angela Klinczar
Miami University
700 East High St.
Oxford OH 45056
GorchoDL@muohio.edu

Mary Klunk
Five Rivers MetroParks
409 E. Monument Ave
Dayton OH 45401
mklunk@metroparks.org

Debra Knapke
The Garden Sage/Columbus State C.C.
873 Clover Dr.
Columbus OH 43235
dknapke@columbus.rr.com

Kathleen Knight
USDA Forest Service NRS
359 Main Road
Delaware OH 43015
jmjolliff@hotmail.com

Marleen Kromer
The Nature Conservancy
6375 Riverside Drive, Suite 100
Dublin OH 43017
mkromer@tnc.org

Tim Lagucki
Columbus Zoo & Aquarium
Box 400
Powell OH 43065-0400
tim.lagucki@columbuszoo.org

Kim Landsbergen Ph.D.
Columbus College of Art and Design
2615 wellesley drive
columbus OH 43221
kim.landsbergen@gmail.com

Diane Larson
U.S. Geological Survey
Minneapolis MN
no.3@email.com

Terry Lavy
The Conservationist
7277 W. Piqua- Clayton Rd
Covington OH 45318
terry.lavy@gmail.com

Deah Lieurance
UF/IFAS Assessment
7922 NW 71 Street
Gainesville FL 32653
dmlieurance@ufl.edu

Dave Liggett
Columbus Zoo & Aquarium
Box 400
Powell OH 43065-0400
dave.liggett@columbuszoo.org

Alexandra (Sascha) Lodge
University of Minnesota
1707 Lindig Street
Falcon Heights MN 55113
saschalodge@gmail.com

Katie Lynch
University of Louisville
209 McCready Ave
Louisville KY 40206
krlynch11@gmail.com

Diana Malas
ODNR Division of Wildlife
4310 E 5th Ave
Columbus OH 43219
diana.malas@dnr.state.oh.us

Keith Manbeck
OIPC Board Member
1305 Kimberly Dr
St. Marys OH 45885
k.manbeck@hotmail.com

Jim Mason
Horticultural Management Inc.
445 Ward Koebel Rd
Oregonia OH 45054
sbatcha1@earthlink.net

Chris May
The Nature Conservancy
101 E Grand River
Lansing MI 48906
cmay@tnc.org

Shannon McCarragher
Northern Illinois University
150 Penny Lane
Sycamore IL 60178
smccarragher@gmail.com

Chuck McClaugherty
University of Mount Union
1972 Clark Ave
Alliance OH 44601
mcclauca@mountunion.edu

Ryan McEwan
University of Dayton
6179 Laurelhurst Lane
Centerville OH 45459
ryan.mcewan@udayton.edu

Catherine McGlynn
Northeast Illinois Invasive Plant
909 Elmwood Avenue, Apt. K-3
Evanston IL 60202
cathy.mcglynn@niipp.net

Rachel McNeish
University of Dayton
2100 south smithville road
Kettering OH 45420
rachel.e.mcneish@gmail.com

Chelsea Merriman
Poster Presenter
2211 Independence Drive
Boise ID 83706
cmerrima@nd.edu

Nicholas Mikash
City of Mentor - Natural Resources
8500 Civic Center Blvd
Mentor OH 44060
mikash@cityofmentor.com

Bill MInter
Goshen College
20111 Regina Rd.
New Paris IN 46553
billfm@goshen.edu

Joe Moosbrugger
Crane Hollow Preserve
18038 State Route 374
Rockbridge OH 43149
joe@cranehollow.org

Karrie Morrow
Columbus & Franklin Co. Metro Parks
1069 W. Main Street
Westerville OH 43081
morrow@metroparks.net

Melissa Moser
ODNR Division of Wildlife
4310 E. 5th Ave.
Columbus OH 43219
melissa.moser@dnr.state.oh.us

Jamee Nirider
Ohio Department of Natural Resources
2045 Morse Rd. Bldg C-3
Columbus OH 43229
Michelle.Comer@dnr.state.oh.us

# Attendees of the Invasive Plants Symposium Sponsored by MIPN

Jessica Peebles-Spencer
Miami University
700 East High St.
Oxford OH 45056
GorchoDL@muohio.edu

William Persons
University of Louisville
1010 Southern Ave
Louisville KY 40218
wepers01@exchange.louisville.edu

Corine Peugh
The Wilds
14000 International Road
Cumberland OH 43732
cpeugh@thewilds.org

Trinity Pierce
The Wilds
14000 International Road
Cumberland OH 43732
cpeugh@thewilds.org

Gary Popotnik
The Wilderness Center
P.O. Box 202
Wilmot OH 44689
gary@wildernesscenter.org

Joanne Rebbeck
USDA Forest Service,
359 Main Road
Delaware OH 43015
jjolliff@fs.fed.us

Lisa Regula Meyer
Kent State University
1433 Cedar St.
kent OH 44240
lkregula@gmail.com

Dafna Reiner
National Park Service
16062 Rt 104
Chillicothe OH 45601
laurusleaf@gmail.com

Lesley Rigg
Northern Illinois University
Zulauf Hall Rm 313
DeKalb IL 60115
parndt@niu.edu

Steve Ross
The Nature Conservancy staff
6375 Riverside Drive
Dublin OH 43017
sross@tnc.org

Alex Roth
University of Minnesota
2139 Scudder St.
Saint Paul MN 55108
roth0487@umn.edu

Colby Sattler
Davey Resource Group
295 S. Water street
KENT OH 44240
colby.sattler@davey.com

Kris Schenk
Columbus Zoo & Aquarium
Box 400
Powell OH 43065-0400
kris.schenk@columbuszoo.org

Michael Schuster
Purdue University
155 South Grant St
West Lafayette IN 47907
schustem@purdue.edu

Robert Schutzki
Michigan State University
221 E. Hamlin St
Eaton Rapids MI 48827
schutzki@msu.edu

SHAWN SHIPMAN
CITY OF DUBLIN
5200 emerald parkway
dublin OH 43017
mkeplar@dublin.oh.us

Daniel Simberloff
University of Tennessee
Knoxville TN
no.2@email.com

Kathy Smith
Ohio State University Extension
6750 Township Road 49
Mansfield OH 44904
smith.81@osu.edu

Jessica Spencer
The Wilds
14000 International Road
Cumberland OH 43732
cpeugh@thewilds.org

Amy Stauffer
Western PA Conservancy/ PA Natural
800 Waterfront Drive
Pittsburgh PA 15222
astauffer@paconserve.org

Doug Stevenson
Graet Parks of Hamilton County
10245 Winton Road
Cincinnati OH 45231
tborgman@greatparks.org

Marne Titchenell
Ohio State University Extension
2355 McCauley Ct
Columbus OH 43220
titchenell.4@osu.edu

Lori Totman
The Dawes Arboretum
7770 Jacksontown Rd. S.E.
Newark OH 43056
latotman@dawesarb.org

Cody Uhas
City of Mentor - Natural Resource
8500 Civic Center Blvd
Mentor OH 44060
uhas@cityofmentor.com

Lara Vallely
Purdue University
401 S. Grant Street
West Lafayette IN 47907
howek@purdue.edu

Major Waltman
Louisville Olmsted Parks Conservancy
PO Box 37280
Louisville KY 40233
major.waltman@olmstedparks.org

Rhonda White
City of Dublin
5200 emerald parkway
dublin OH 43017
mkeplar@dublin.oh.us

Jennifer Windus
ODNR - Division of Wildlife
4310 E. 5th Avenue
Columbus OH 43219
sharelle.jones@dnr.state.oh.us

Danae Wolfe
OSU Extension
2525 State Rd
Cuyahosa Falls OH 44223
wolfe.540@osu.edu